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THE GIFT OF
Mrs. W. L. Stebbings

CIVIL ENGINEERING SPECIFICATIONS AND CONTRACTS

PREPARED BY

RICHARD I. D. ASHBRIDGE

CIVIL ENGINEER

MEMBER OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

"For which of you, intending to build a tower, sitteth not down first, and counteth the cost, whether he have sufficient to finish it. Lest haply, after he hath laid the foundation, and is not able to finish it, all that behold it begin to mock him, saying, This man began to build, and was not able to finish."—St. Luke XIV: 28, 29, 30.

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GIFT OF
MRS. W. L. STEBBINGS
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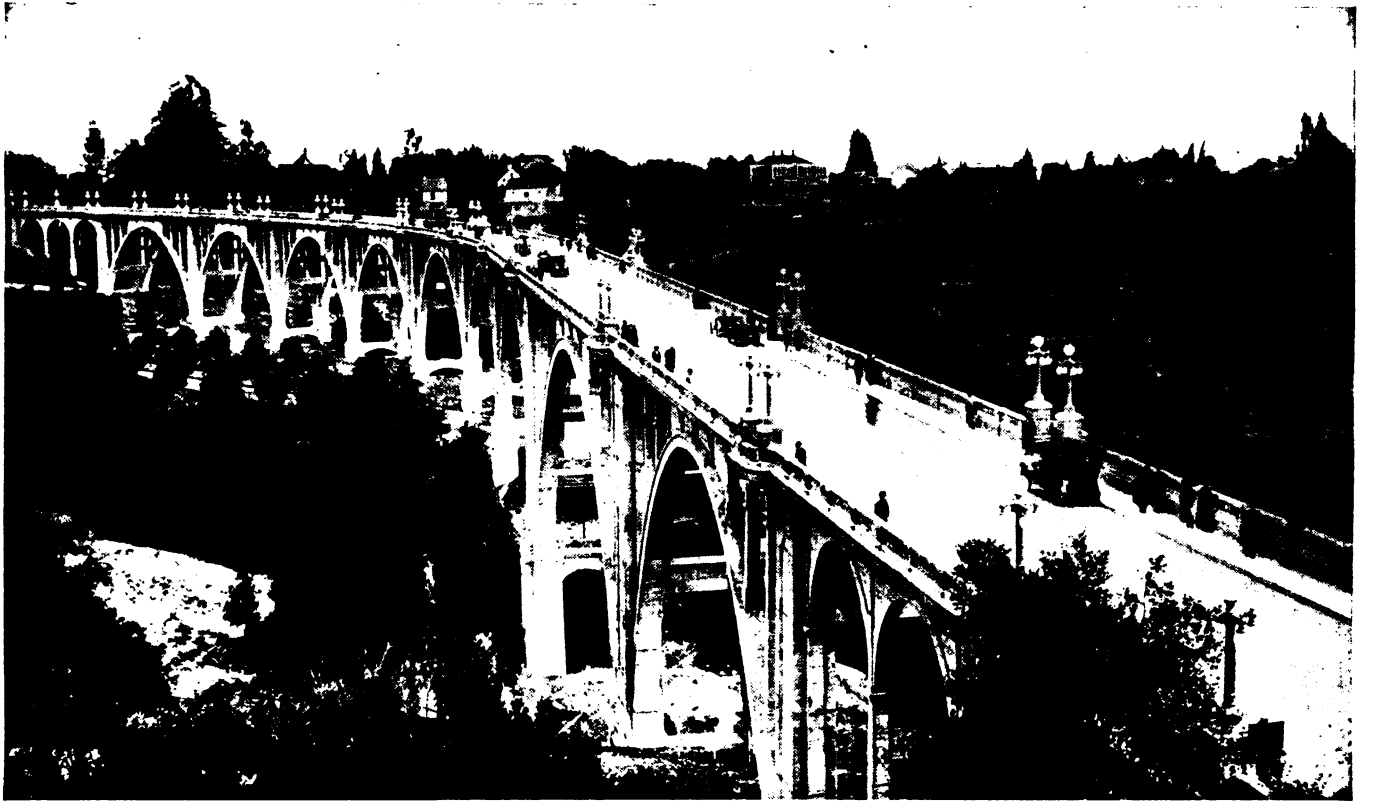
INTRODUCTION

IN engineering work, often involving millions of dollars and the labor of thousands of men for months, there can be no more important matters for the interested parties to consider than exactly what is to be done, how it is to be done, and what it is going to cost. An important contractual relation, which is to last sometimes for years, is to be entered into and, to avoid trouble and litigation, the "meeting of the minds" must be exact on all points. On the one hand the interests of the corporation or individual for whom the work is to be done must be carefully safeguarded; on the other hand, no injustice must be done the contractor, nor any provisions introduced or omitted which will prevent him from making an honest profit on his work.

¶ The author, who has a wide experience in Civil Engineering work, has tried first to develop a logical system of preparing specifications, and to present a method of avoiding the mistakes and omissions all too common in papers of this kind. He has also attempted to cover all types of specifications from railroad work, bridges, culverts, excavations, fills, tunnels, and road-beds to country and city paving. In addition to typical specifications, the proposal, agreement, and contract forms are discussed and illustrated. Advice is also given as to the points to be considered and avoided in drawing up a set of specifications and in properly drafting a contract. Altogether, a thorough presentation of this important subject has been given and it is hoped that this volume will be a distinct contribution to engineering literature.



BEAUTIFUL REINFORCED-CONCRETE BRIDGE SPANNING ARROYO SECO, PASADENA, CALIFORNIA

This is an excellent example of an artistic, and at the same time well-designed, bridge and shows a marked departure from the ponderous massing of concrete usually found in reinforced-concrete bridges. The bridge is 1,475 feet long and 149 feet high, and consists of nine large and six small spans. The designing engineers were Waddell and Harrington of Kansas City; the contractors, The Mercerreau Bridge and Construction Company, Los Angeles, under the supervision of the Pasadena City Commissioners.

CIVIL ENGINEERING SPECIFICATIONS AND CONTRACTS

PART I

INTRODUCTION

In the preparation for letting a piece of work, the Engineer must, by drawing and written description or specification, set forth his ideas. He must also make estimates of the cost of the work under different methods of construction to determine the least expensive method of accomplishing the desired result and, if he wishes to let the work, he should make such public announcements as shall reach the greatest number of desirable contractors.

In order to insure an early execution of the construction, it is his duty to prepare the form of bid or proposal, with the instructions to bidders and, later, after attending to the opening of bids, he must adopt a form of articles of agreement and fix a bond, which, together with the specifications, drawings, and proposal, form the contract. These various steps will be treated in the following work, in the order of their importance in the contract from the Engineer's point of view.

GENERAL INSTRUCTIONS

Engineering. Engineering may be defined as the science or art of utilizing the forces and materials of Nature with the greatest amount of economy. It has been defined epigrammatically as "the science or art of making a dollar go the farthest". Engineering is divided into Civil Engineering, Mechanical Engineering, Electrical Engineering, Mining Engineering, Hydraulic Engineering, Gas Engineering, Chemical Engineering, Agricultural Engineering, etc. According to modern usage, *Civil Engineering* is confined strictly to fixed construction, such as railways,

bridges, docks, tunnels, sewers, aqueducts, canals, lighthouses, dams, breakwaters, etc.

The Engineer. It is necessary that the two parties to a contract for the execution of any important construction work have some one in authority to decide all questions in dispute between them, and to see that the work is carried out in accordance with the requirements of the contract. This person is generally the Engineer who designs the work, although in some States, unless the Engineer's name is written in the articles of agreement, his decisions are not binding.

It is his duty to take a perfectly neutral position between the two parties, and to see that the work is carried out in strict accordance with the contract. He should work in harmony with the contractors, give all possible aid to accelerating the work, and take pains to secure work and material strictly up to the standard of requirements in the specifications. Although he is usually in the employ of the party for whom the work is being done, as the arbitrator his decisions must show perfect impartiality, so that both parties will admit their justice; but in order that there may be few questions at issue between the parties to the contract, the Engineer must be thoroughly familiar with the character of the work he is designing and the quality of the materials entering into it.

Contract. A contract is a written or verbal agreement between two or more parties specifying terms, conditions, etc., under which certain obligations are to be discharged. A contract for engineering work generally consists of the Advertisement, the Proposal (including the notice to bidders), the Drawings, the Specifications, the Articles of Agreement (generally spoken of as the contract), and the Bond, which is usually required to insure the carrying out of the contract.

It is the Engineer's duty to see that he obtains the greatest amount of the best work for the least expenditure of money. Experience has shown that to accomplish this end he should first determine the exact character of the structure which is to be built and, in addition to the drawings, which are generally necessary, he should prepare the following: (1) The form of Specification; (2) the Agreement; (3) the Proposal, or form of bid,

including the notice to bidders; (4) the Advertisement. They are given above in the order of their importance to the Engineer and Contractor, and in that order they will be treated.

It is essential that all parts of the contract be prepared carefully in order to avoid misunderstanding. Many disputes are avoided by requiring contractors to make their bids on a regular form of proposal, furnished by the party for whom the work is to be done. In the case of small or unimportant work, the bond is often omitted. In some cases drawings are not necessary, and in many cases the work to be done is not advertised, as the work may not be of sufficient magnitude to warrant the expense, and as many corporations keep a list of the names of contractors who are regularly asked to bid on projected work. Of the above, the drawings and the specifications are the most important to the Engineer and the Contractor, as they are the guide for both in the execution of the work and are constantly in use during construction; hence, for convenience, the specifications and the drawings are often so prepared that they can be readily detached from the other components of the contract.

Drawings. Very few contracts for construction work are drawn without plans of some kind. They should be made accurately and on a scale large enough to show all details conveniently and clearly. All dimensions and distances should be written carefully upon the parts of the detail drawings to which they refer, and all dimensions should be checked by a second draftsman. The distance to be embraced by the figures should be indicated by dotted arrows. The drawings should be so accurate and so complete that there can be no question as to the intention of the designer even to the smallest detail. In preparing the specifications, the designer should keep a memorandum tablet on his table and jot down every thought that may be of service. The value of a drawing depends upon its accuracy.

The sheets should be uniform in size, carefully lettered or numbered for reference, and should be clearly and plainly titled. They should also show the scale, the date when completed, the initials of the draftsman, and the initials of the checking draftsman.

Maps should show a meridian and magnetic variation, if the latter be known.

The Government prohibits the letting of a contract without an accompanying plan; certain city ordinances and charters have the same prohibition. The requiring of plans to accompany the contract is to assure the competing Contractors that they are bidding on the same basis.

Contracts are frequently drawn for patented or special structures, without plans; in such cases, the Contractor furnishes a working drawing, subject to the approval of the Engineer, after the contract is executed. The specifications for such work are usually confined to a general description of the work required and a guarantee of results to be obtained by the Contractor, without setting forth the detail of construction or method. Sometimes plans are tendered by the bidders—thus allowing the Engineer to make comparison and choice of the different ideas submitted. This method of letting contracts is not recommended, but as the various branches of Engineering become more specialized and as most of the leading contracting firms have competent engineers who are specialists in their particular line of construction, it becomes necessary for the busy Engineer, with a general practice, to make use of the specialist in order to keep pace with modern construction methods.

Specifications. The specifications define the exact relations between the parties to the contract; they are supplementary to the drawings and should be embodied in the contract. They are a written description of the work to be performed and should show specifically whatever features are not shown on the drawings. They should define the quality and quantity of materials; the methods of construction; the nature of the workmanship; the manner of conducting the work; and the general conditions and stipulations.

The specifications must be most carefully drawn, leaving nothing to the imagination, as they are the guide to both Engineer and Contractor throughout the execution of the work. Great care must be taken that no important special and general clauses be omitted. They should set forth clearly and with great exactness what is to be done.

The Contractor is supposed to be experienced in the special class of construction to be undertaken, and should not be dictated to as to methods—except in very special cases—and he should be held strictly responsible for results. In some cases the Engineer may desire a specially manufactured article or material, or a special method to be used in accomplishing a certain result; in which case it is necessary to incorporate the specifically-mentioned article and the method of doing the work in the specification. If the specified article is inherently unsuitable for the purpose intended, or the method required does not accomplish the desired result, the Contractor must not be held for the results, as he is not free to act according to his own ideas and cannot be responsible for the mistakes of the Engineer. Either leave the methods and means entirely to the Contractor who is held responsible for results, or let the Engineer assume entire charge of methods and means and state that the Contractor will not be held responsible for results. To attempt to follow both courses at the same time is inequitable and will be so found if carried into the courts of law. In plain words, the specifications should point rather to the finished structure than to the method of accomplishing the work.

General and Specific Clauses or Provisions. Specifications are usually divided into general and special clauses or provisions. The general clauses are those that are applicable with slight variations to almost any important piece of construction work, while the special clauses refer to the character of the material, the details of construction, the special features and ideas to be incorporated, and no details should be spared that would add to the clearness of description in every step of the proposed work. All clauses should be numbered and properly headed, preferably by a marginal note, for convenience of reference. The general clauses should be segregated from those of a specific nature, thereby avoiding errors of omission.

General clauses or provisions describe the general relation of the parties involved, the time for beginning and completing the contract, payment for the work, the Contractor's liability, the special duties of the Contractor, inspection, change of plans, interpretation of plans, measurements, conduct of the work,

maintenance of completed work, etc. It is advisable for the Engineer to have a list of the general conditions which are applicable to most contracts before him and, upon completion of the rough copy, to check over the clauses to see that all the conditions have been included. The writer has a list of over one hundred headings that he endeavors to embody in every specification drawn; although it is not necessary to have a special clause for each heading, he has found that this is the surest method to prevent omissions of necessary clauses.

Great care must be taken that clauses do not contradict each other; that they be not at variance with the plans; and that ambiguous description is not introduced.

Clearness of Statement. The wise and careful Contractor will note every detailed provision of a specification, and will bid accordingly, expecting to do no more than is required in the contract. Hence it is necessary that the Engineer set forth every detail fully, clearly, and concisely. Work should be so designed and described as to require no alteration in the course of construction.

The specification requiring the Contractor to ask the Engineer for an explanation of its meaning is not clearly drawn. The Engineer must not suppose that the Contractor will take anything for granted; he must draw his specification in such a manner as to cover the work, in general and in particular, in every detail.

It is of the greatest importance that there be no ambiguity and no omission of words. The clauses should be couched in the simplest language and the sentences should be short and to the point. Bad English, careless punctuation, and verbosity are to be carefully avoided. The incorrect placing of a comma has caused the loss of many thousands of dollars. Write so clearly that there will be no occasion to take the specification to court to decide what is the "spirit" of the contract; that is, what was intended by the writer of the contract and what the parties to it should understand by it. Repeat words or sentences, if it is found that the meaning is thereby made clearer.

Precision. While it is not always possible to prescribe exact quantities, the word "about" is to be avoided in specification

writing. Be precise in all descriptions; ask for nothing that you do not know to be practicable, and be definite and specific in every detail. The units of measurement to be employed should always be clearly stated.

Knowledge Required of Engineer. The Engineer must have a thorough knowledge of every detail of the work before he attempts to describe what the Contractor is to accomplish under the specification; even when understood perfectly by the Engineer, it is often very difficult to describe exact requirements.

Avoidance of Unusual Conditions. Specifications should be so drawn that the best class of material and workmanship consistent with the amount of money to be expended on the undertaking be obtained. Avoid conditions which are unusual and beyond the ordinary requirements of good practice, and which are not absolutely necessary to the results desired. The Contractor will generally bid a figure out of all reasonable proportion, to insure himself against loss on work of a character with which he is entirely unfamiliar. Remember that Engineering has been defined as "the science or art of making a dollar go the farthest". Many young engineers are prone to introduce into their work some new idea of their own, of doubtful utility, for the sake of novelty and self-advertisement, where a more conservative man will follow the beaten road of approved practice.

Materials Employed. The materials of construction should, to as great an extent as possible, be those readily found in the local markets and in the neighborhood of the work. This does not mean, however, that any inferior or unsuitable material may be allowed to enter into the work; on the contrary, the most approved practice should be required both as to materials and workmanship. The Engineer may be sure that he will not get a better quality of material than that specified, and will often get a poorer one. Be careful in regard to specifying materials of special manufacture, as the Engineer must be above the suspicion of favoring any particular make or brand. It is wise to set as a standard the best brand on the market and then require it, or its equal. It is generally best to set forth the requirements or tests that a material must fulfill, in preference to naming the special manufacture.

Extra and Additional Work. What constitutes *extra* and *additional* work is the most frequent cause of controversy between the Engineer and the Contractor; therefore, the greatest care should be used in specifying what should constitute each. Extra work may be defined as work entirely unforeseen at the time of the drawing of the contract; while additional work is work of the same quality and workmanship as that described in the specification, which can be foreseen but not accurately calculated. The proposal should include unit prices for the various items of materials and workmanship, which it is thought may be required to complete the construction, over and above the work described in the specifications, in order that there be no cause for controversy over the items of additional work. But where there have been omissions in the requirements of the specifications; when alterations, changes, and additions become necessary; where errors have been made in lines or grades; where new methods or materials are experimented with by the Engineer; where damaged work is replaced; or where the work has to be extended to secure greater strength, durability, or stability, there is frequently more or less controversy as to just what shall constitute extra work under the contract. This trouble can be avoided by defining clearly just what work is to be done by the Contractor, and by requiring nothing of him beyond the lines of the work so defined.

Dividing Line between Contracts. The dividing line between contracts should be very carefully described and, where there are several contractors on one piece of work, the exact limits of the work to be performed by each one must be set forth most carefully.

The work for each of the several contractors should be described under separate headings, care being taken that each contractor agree to leave his work in such condition as to work no hardship on the one following him.

Verbal Information to Contractor. A clause in the specification should state that any information, whether verbal or otherwise, secured by the Contractor from the Engineer or his assistants prior to the signing of the contract is not binding, and that only the information as shown on the plans, or set forth in the

specifications, has bearing on the contract. The specification is, and should be stated therein to be, a part of the contract. The plans and specifications should give as full information as possible as to conditions and difficulties that may be met with, such as soundings, borings, character of material, amount of water to be encountered, etc.; and any special difficulties known to the Engineer should be noted in the specification, and no information of use to the Contractor in making up his bid should be omitted.

Mistakes in Plans and Specifications. Finally, every precaution must be taken to prevent mistakes in the plans, and omissions or conflicting clauses in the specifications. Every possible check against errors should be made use of. When errors are discovered in the course of the work, no time should be lost in admitting them and setting about to rectify them. The principal object is to produce a finished piece of work, constructed according to the best approved practice, that will be a credit to the Engineer, as well as to every one who has had a hand in its construction.

GENERAL PROVISIONS

DETAILS PRIOR TO BEGINNING WORK

Grouping Provisions. There is a great difference of opinion as to the proper location of certain general provisions in contracts. Some place them in the articles of agreement, while others place the same clauses in the specification. The writer advises keeping the general clauses together as much as possible, grouping them so as to indicate their character and placing them almost entirely in the specification, making the contract as short and concise as possible. The proper grouping is very difficult, as many of the clauses might be placed in any of several groups.

In drawing up specifications it is a good practice for the Engineer to keep before him a list of general provisions covering all cases and, while all the provisions will not apply to any one contract, this will be a great aid in preventing omissions. Some of the following apply to one class of work only and have been grouped under the various headings, all being written as though one of the parties to the contract was the "Company", the other the "Contractor". Of course, the wording would be modified

in case the work were being done for a municipality or an individual.

Careful Statement of Definitions. To prevent disputes, the principal parties to the contract and their representatives should be clearly defined; hence the necessity of a clause of the following character in most specifications:

Definitions. The following words and expressions used in this contract shall be defined and construed as follows:
City: The City of_____.
Director: The Director of the Department of Public Works of the City of_____.
Chief Engineer: The person holding the position or acting in the capacity of the Chief Engineer of the_____ Company.
Engineer: The Chief Engineer of the_____Company, or, in his absence, his regularly appointed and authorized Assistant Engineer, and Inspectors representing him, limited to the special duties intrusted to them and to no other employe of the_____Company.
Contractor: The individual, parties, firm, or corporation with whom or with which the contract is made, or an authorized agent thereof.

Other words often have to be defined, such as Owner, Purchaser, Trustee, Board, Directors, President, Treasurer, each of which should be clearly defined so that there can be no possible question as to its precise use.

DRAWINGS, PLANS, ETC.

The following group of clauses relate to drawings, or plans, and notes on them:

Construing Specifications and Plans. To avoid disputes and litigation, it must be distinctly understood by the Contractor that the Engineer of the Company shall construe the specifications and approved plans; and explain any obscurity therein; and shall have the right to correct any errors or omissions in either and decide as to their purpose and intent; and his decision upon any doubtful or disputed point shall be final, conclusive, and binding upon the Company and the Contractor. The action of such correction shall be in force from the time the Engineer gives due notice thereof in writing.

Plans and Specifications of Equal Force. The approved plans and the specifications shall be of equal force and effect and, in case of discrepancy between the plans and the specifications, or between the plans and the details, or any lack of agreement in measurements upon different plans, or different figures upon the same plan, they must be submitted to the Engineer for interpretation before beginning construction of the work. Dimensions shown in figures on the plans shall have preference over the scale.

General Drawings. The Company will furnish to bidders drawings giving all general dimensions and sizes, and such partially detailed drawings as may be required to cover special features. After assigning the contract, such other drawings as may, in the judgment of the Engineer, be required, will be furnished by the Company. The Contractor shall prepare drawings for shop work, which shall include all details required to supplement and complete the general and partially detailed drawings furnished by the Company; and he shall submit 3 blueprints of each sheet for the approval of the Engineer. After approval, if required, additional prints shall be furnished. The approval of the Engineer shall in no way relieve the Contractor from responsibility for the correctness of all detail drawings before going to the shop, nor for the accurate and complete execution of the work.

Work in Accordance with Plans. The work and all its appurtenances shall be built of material, size, and dimensions, on the lines, to the depths, and in the manner shown on the plans filed in the office of the Company. No deviation from them will be allowed unless by permission in writing from the Engineer.

Record Drawings. The Contractor, upon completion of the work, shall furnish 3 complete sets of blueprints on linaura, of detail drawings of the machinery and all appurtenances; each set shall be neatly bound in cloth for record drawings of the work embraced under the contract as a whole.

Plans and Specifications. The approved plans and a copy of the specifications are to be kept constantly at the work by the Contractor or his authorized foreman.

Necessary to Render the Work Complete. If any workmanship or materials be required, which are obviously necessary to carry out the full intent and meaning of the plans, details, diagrams, and specifications, although the same may not be either directly or indirectly so specifically noted by drawings or specifications, the Contractor is hereby bound to consider and provide for the same in his proposal for the work, as fully as if they were so specifically denoted, and shall execute the same without charge or claim therefor.

Notes upon Drawings. Contractors proposing for any of the work under these specifications will be expected to examine all the notes upon the plans, which are intended to form a part of the specification. No consideration will be given to any claim that these notes have been overlooked.

Verbal Agreements. This contract shall in no wise be affected by verbal agreements or inferences from conversations previous to or subsequent to its execution.

MEASUREMENTS, LINES, AND GRADES

The following paragraphs may be grouped under Measurements, Lines, and Grades:

Lines and Grades by Engineer. The work shall be laid out on the ground by the Engineer, who shall direct the lines and grades that are to be observed, and all marks given by him shall be carefully preserved by the Contractor, who shall provide such stakes, forms, and assistance in doing the work as may be demanded of him by the Engineer.

Marks and Stakes to be Preserved. Contractors must carefully preserve bench marks and stakes and, in case of willful or careless neglect, they shall be charged whatever the Engineer shall consider an equitable amount to cover damages arising from such negligence, the same to be deducted from the amount due upon the completion of the work.

Work to Conform to Lines, etc. All construction work shall conform to the lines and stakes set out by the Engineer, and any increase of labor or material required, due to the neglect of these lines and stakes, shall not be estimated or paid for.

Standard of Measure. All measurements are given on the plans and shall be measured in United States standard feet. Where vertical dimensions are preceded by the sign + or —, they refer respectively to above or below an established horizontal plane called datum, which is.....feet above (or below) mean high water and.....feet above (or below) the mean low water in the.....at.....

Measurements. All quantities shall be determined by measurements in United States standard feet, made to the prescribed lines. No work outside these lines shall be paid for. No constructive conventional measurement will be allowed, any rule or custom in the section of the country through which the road passes, to the contrary notwithstanding.

Quantity Estimates. It is distinctly understood by both parties to a contract, that the quantities of material of all kinds

shown on the plans or in the specifications are merely approximate, and will not in any manner affect the final settlement because of the fact that at the time of drawing up the specifications it was impossible to determine them accurately.

The Company reserves the right to require the use of whatever materials may be necessary for the safe and efficient temporary and permanent construction of the work; also the right to increase or diminish the quantities to the extent found necessary by the Engineer.

FULFILLING THE CONTRACT

EXECUTION OF WORK

The following clauses are generally grouped under Execution of the Work:

Prosecution of Work. The Contractor shall commence, prosecute, and complete the work in all its parts in the most energetic and workmanlike manner, and shall prosecute the work at and from as many different points, at such times, in such parts, and with such force of workmen, as the Engineer during the progress of the work may determine.

Should the necessary land or right of way not be procured at any place when the Contractor desires to work thereon, he shall distribute his forces to such other points as may be designated by the Engineer, without any claim for damages for failure to procure such land or right of way.

Delay in Procuring Right of Way or Land. The Company shall procure the necessary right of way and lands needed for the work to be done under this contract; but it is agreed and understood that, until the said Company shall have procured all the right of way or land required for this contract, the Contractor shall commence work, or make arrangements for commencing work, entirely on such ground as the Engineer may designate. The Contractor shall not have any claim for damage or detention by reason of delay in procuring titles to lands, but he shall be entitled to an extension of time on each part of the work on which he was prepared to commence, equal to the time lost from and after the day when he was so prepared, provided such detention shall exceed 10 days. In all such cases, however, the Contractor shall notify the Engineer in writing when and where he desires to commence work.

Duties of Contractors. Contractors will be required to give their personal attention and supervision to the work and will not be allowed to sublet the whole or any part of the same with-

out the consent of the Company having been given thereto in writing.

Contractors must satisfy themselves by a careful personal examination of the nature and location of the work for which they bid, of the general form of the surface of the ground, and all other matters which can in any way influence their contracts; and no information upon such matters derived from maps, plans, profiles, drawings, or specifications, or from the Engineer or his Assistants, shall in any way relieve the Contractor from any risk, or from fulfilling any of the terms of this agreement.

Borings. The Company does not guarantee the correctness of the borings nor the nature of the materials shown upon the plans. The Contractor must assume all risks resulting from any differences from the borings found to exist when the construction is under way.

All loss or damage arising from any unforeseen obstructions or difficulties encountered in the prosecution of the work shall be sustained by the Contractor. The soundings and borings, and the profiles based thereon, are to be taken merely as guides for the Contractor in bidding, and must not be construed to relieve him from responsibility in determining for himself the nature of the materials which will be encountered.

Care of Materials. The Contractor shall receive, care for, and be responsible for all materials purchased by the Company and delivered to the said Contractor at the point herein designated. In case of loss by fire, flood, breakage, theft, carelessness, etc., the Contractor shall make good any loss.

NOTE.—This clause is necessary when the Company is supplying part or all of the materials of construction, such as spikes, bolts, etc., in track-laying contracts; lumber or iron in bridge work, when the contract is for the erection of the material only, and parallel cases.

Materials to be Furnished. The Contractor shall furnish all materials required, which shall be in full accordance with these specifications and the general and detail drawings, as they may be approved by the Engineer, and shall also furnish all labor, tools, and machinery necessary and all must be of the kind best adapted to the efficient, prompt, and safe execution of the work.

Right of the Company to Employ Additional Men. If at any time, in the judgment of the Engineer, the Contractor shall neglect to prosecute the work with a force sufficient for its completion within the time specified, the Company may employ such number of working laborers and foremen as, in its opinion, may be necessary to insure the completion of the work within the

time specified in the contract, at such wages as it may find necessary or expedient; and may pay all persons so employed, and charge all amounts so paid as so much money paid to the Contractor under this contract.

Extension of Time. If the Contractor shall not complete the work within the time specified in the contract, and the Company shall, notwithstanding such failure, permit the Contractor to proceed with or complete the work as if such time had not elapsed, such permission shall not be deemed a waiver in any respect by the Contractor of any forfeiture or liability for damages or expense thereby incurred, arising from such noncompletion of the work within the time specified and covered by the "Liquidated Damages" clause of this contract; but such forfeiture or liability shall still continue in full force against the Contractor as if such permission had not been granted.

NOTE.—Where no time for completion of the work is given, the work must be completed within a reasonable time.

Twelve o'clock midnight of the day named in the contract as the date of completion is the limit of time unless a certain hour has been specifically named. Time clauses should state whether Sundays and holidays are excluded from the specified period.

What Prices are to Include. The prices specified in the accepted proposal and contract shall include the supply and erection, in a good, sound, substantial and workmanlike manner, of all dams, flumes, pilings, shorings, sheathing, shafts, forms, centering, false works, tramways, machinery, and scaffolding; also pumping, labor, workmanship, tools, fuel, and materials necessary for both permanent and temporary works, including all the items herein mentioned (unless specifically stated otherwise) for the prompt completion of the whole work proposed for, shown on the drawings, and described in these specifications. All materials and workmanship shall be of the best quality and description, and the work perfect and complete in all its parts.

NOTE.—This provision will change, as to the different items included, depending on the character of the work; for while the clause is applicable to a sewer, or pipe-laying contract, it would not cover the requirements for track laying.

INSPECTION OF WORK

The following four clauses are grouped under Inspection:

Inspection During Construction. The Contractor shall at all times afford every facility for inspecting materials and workmanship. Any materials or workmanship not in accordance with

the plans and specifications shall be replaced with approved material or workmanship, or both, within the time fixed by the Engineer; and all rejected materials shall be immediately and entirely removed from the site of the work. If, after written notice to the Contractor, the rejected materials are not removed or the condemned work built anew within the time fixed, the Company shall be at liberty to remove the rejected materials and supply new materials, or build anew any unapproved work, at the expense of the Contractor, and the cost thereof shall be deducted from any money which may be due him.

Nothing in this contract shall be construed as vesting in the Contractor any right of property in the materials used, after they have been attached or affixed to the work on the soil; but all such materials shall, upon being so attached or affixed, become the property of the Company.

Materials and workmanship may be inspected at any time. All structural steel shall bear the Inspector's mark of acceptance. The Contractor shall execute the work in the presence of an Inspector at all times; work in absence of same shall be subject to rejection.

Final Inspection. The final inspection and acceptance of the work will take place after construction; and any inspection and acceptance of materials and workmanship at the site of the work, foundries, shops, etc., to facilitate the progress of the work, shall not prevent rejection of such materials and workmanship thereafter, if the same be found unsuitable or imperfect.

Cost of Engineering and Inspection. The cost of engineering and inspection, after the expiration of the time agreed upon in the contract for the completion of the work, shall be at the expense of the Contractor, and such cost shall be deducted from the amount due the Contractor at the time for final payment.

Labor Furnished to Inspector. If required, the Contractor shall furnish such labor as the Engineer shall deem necessary to assist in the inspection of materials to be embodied in the construction under this contract and to assist in giving lines and grades on the work, all free of cost to the Company.

NOTE.—This provision is unusual and is used or enforced only in comparatively small contracts, or when it would be unjust to expect the Company to keep a corps of engineers and inspectors on work indefinitely to accommodate a Contractor who is in default with his work. On small contracts, requiring little or only occasional staking out, or where the work is in remote sections, it is customary to get the assistance of some of the Contractor's laborers to drive the stakes, cut brush, etc., to avoid the expense of maintaining a large corps constantly on the work.

PROTECTIVE AND LABOR CLAUSES

Builders' Insurance. The Contractor will be required to take out from time to time, in an approved company, a Builders' Insurance Policy covering the value of all materials liable to injury by fire, incorporated in or brought to the work, and shall assign same to the Company. The policy shall be approved as to form and amount by the Engineer.

Freezing Weather. The work shall be carried on in cold weather only at such times and in such manner as directed by the Engineer. When work is done during freezing weather, if required, the Contractor shall provide proper facilities for heating the materials entering into the work and shall thoroughly protect the new construction from damage caused by the elements, during and after building. Upon the suspension of work due to freezing weather, all new work shall be protected and the grounds left in good order.

Competent Men and Discharge for Cause. The Contractor shall employ only competent men; and he shall discharge any foreman or other employe who shall, in the judgment of the Engineer, be unfaithful, unskillful, or remiss in the performance of his work, or guilty of riotous, disrespectful, or otherwise improper conduct; and no person so discharged upon this work, or any other work done for the Company, shall be employed again by the Contractor upon the work to be done under this contract without the written consent of the Engineer. The work under this specification shall be subject to all federal, state, and (or) municipal laws, or regulations, in regard to the employment of laborers, workmen, and mechanics and also those laws regulating the hours of employment of such employes; and further, before receiving each payment, the Contractor, if required by the Engineer, shall furnish an affidavit that such laws have been faithfully fulfilled.

Employment of Labor. The Contractor, in the construction of the work, shall give preference in employment to citizens of the commonwealth; and in the employment of mechanics and laborers, where citizens of the commonwealth are not available, shall give preference to citizens of the United States who are not citizens of the commonwealth. Persons employed in the performance of manual labor under this contract shall not be required to work more than.....hours in each day, and.....hours shall constitute a day's work.* The Contractor shall neither directly nor indirectly require as a con-

* An 8-, 9-, or 10-hour day should be specified, according to local laws and circumstances.

dition of the employment of any person that the employe shall lodge, board, or trade at a particular place or with a particular person, but every employe shall lodge, board, and trade where and with whom he elects.

Foreign Corporations. The Contractor, if a foreign corporation, shall file with the Company, if so requested, duly authenticated copies of its charter or certificate of incorporation.

NOTE.—It is of the greatest importance that a corporation, attempting to do business in a State other than that under whose laws it was incorporated, secure a license and certificate to do business in said State as, in many States, without such license, the corporation cannot enforce its claims in the courts. As the laws differ in every State, it is advisable that the Engineer secure the advice of a local attorney at law, of good standing, to advise in regard to the legal provisions of the contract.

MISCELLANEOUS OBLIGATIONS OF CONTRACTOR

Orders and Instructions. The Contractor must strictly follow, without delay, all orders and instructions of the Engineer or his authorized assistant, in the prosecution and completion of the work, and every part thereof.

Personal Attention. The Contractor is required to give his personal attention to the faithful prosecution of the work, and not to sublet or assign the same, without the written consent of the Company, but to keep it under his own control; and, in case of his absence, to have a competent representative or foreman on the work, who shall receive orders and directions from the Engineer and Inspector and have the same carried out without delay, and who shall have full authority to supply men, material, and labor immediately.

Time of Commencement and Completion. The Contractor shall begin work within.....days from the date of the notice given to that effect by the Engineer, and he shall complete all the work under this contract in the time specified, which will be reckoned from the date of said notice.

Delays. No charge shall be made by the Contractor for hindrance or delay from any cause during the progress of any portion of the work embraced in this contract; but such hindrance or delay may entitle him to an extension of time allowed for completing the work, sufficient to compensate for the detention, to be determined by the Engineer, provided the Contractor shall give the Engineer immediate notice, in writing, of the cause of the detention.

A contractor on any one or more of several sections, into which the work may be divided, will not be allowed any claim

for delay on account of any act of a contractor or contractors on a neighboring section or sections.

Use of Coal under Boilers. The Contractor shall in all cases, where steam power is employed in streets, use anthracite coal under the boilers for generating steam and, where ordered by the Engineer, shall provide electric power for operating all power-driven machinery.

Filling-In of Old Drains. All sewers, culverts, drains, or basins met with and rendered unnecessary, or becoming disused by the construction of the work herein contemplated, must be filled in, and the street or ground over their site must be restored, without extra charge.

Location of Underground Structures. Where existing sewers, water or gas mains, electric and other conduits, met with during the progress of the work, are shown upon the plans, the locations of the structures are intended to be approximate only. The Company will not be responsible for any omission upon the plans as to the location of such sewers, pipes, or conduits met with in excavation, nor for any errors in locations due to incomplete or faulty records.

Buildings for Engineer and Inspector. The Contractor shall provide at least 120 square feet of floor space in a suitably heated, satisfactory building with doors, windows, locks, etc., near the work, for the use, when required, of the Engineer and Inspectors in charge of the work. Telephone service shall be furnished by the Contractor for the use of the Engineer and Inspectors in charge.

NOTE.—While unnecessary in some cases, it is always advisable to have a private room for the Engineer or Inspector where plans and instruments may be safely kept.

Work Day and Night. The work shall be carried on day and night, if necessary, to complete within the time specified.

Pipes and Electric Wires. The Contractor shall take care of all pipes and electric wires encountered on the work, see that they are properly protected, that they are raised and lowered when necessary, and that they are not injured in any way; all damage done to such property shall be paid for by the Contractor. He shall maintain the flow of drainage, whether on the surface or underground. The cost of all such work shall be included in the price bid.

Property of Contractor. Generally, all waste materials excavated, or removed from within the required limits of the excavation, shall be considered the property of the Contractor;

excepting private property, bridges, or parts thereof, water and gas pipes, which, in case they are not required to be replaced, shall be removed to such locality as may be directed by the Engineer. The materials excavated shall be reserved for better construction, support, and protection of the work when required.

When the work under this specification extends through private property, all excavated material not required for the proper construction of the work, and all standing timber, if claimed by the owner of the property, shall not be removed from the ground. If not claimed by the property owner, the material shall be removed and the ground left clean, as required by these specifications.

Examination of Finished Work. The Contractor shall furnish—if deemed advisable by the Engineer—all necessary facilities for making an examination of any work already completed. If the work is found defective in any respect, the Contractor shall defray all expense of such examination and of satisfactory reconstruction. If the work is found satisfactory, such expense will be allowed for.

Material Specified. Where materials are called for specifically by name of the manufacturer, this specification is intended for a standard of style and quality only; but no deviation from or substitution for this material will be permitted without written permission from the Engineer.

Risks from Floods, etc. The Contractor shall assume all risks from floods and casualties of every description; all damage to grading, bridges, trestlework, sewers, masonry, and all other kinds of work not herein specified, from high water, rains, fire, or from any cause whatsoever; and the work so damaged shall be replaced at the expense of the Contractor. In case of any such accident he shall give immediate notice to the proper authorities.

Sanitary Regulations. Necessary sanitary conveniences for the use of laborers on the work, properly secluded from public observation, shall be constructed and maintained by the Contractor in such a manner and at such points as shall be approved by the Engineer, and their use shall be strictly enforced.

Shanties. The building of shanties or other structures for housing the men will be permitted only at such places as the Engineer shall approve, and the sanitary condition of the ground in or about such shanties or other structures must, at all times, be maintained in a manner satisfactory to the Engineer.

No Spirituous Liquors. The Contractor shall neither permit nor suffer the introduction or use of spirituous liquors upon or about the works embraced in this contract, or upon any grounds occupied by him.

Roads to be Opened. The Contractor shall, immediately after signing the contract for the work under this specification, proceed to open and maintain such good and safe roads and paths for foot and horse travel, along the whole line of the work herein described, as the Engineer may direct; and on portions of the work where there are no highways convenient for the wagoning of supplies, he shall open and maintain such wagon roads as may be directed by the Engineer, who also shall decide what extra amount, if any, he shall be entitled to for this work.

NOTE.—This clause is applicable only to such classes of work as railroads, canals, extensive sewer and pipe-line contracts, and reclamation work.

Contractor Responsible for Violation of Laws. In all operations connected with the work embraced in this contract, the Contractor shall be held responsible for any failure to respect, adhere to, and comply with all local ordinances, and all state and national laws controlling or limiting in any way the actions of those engaged upon the work, or affecting the transportation or disposition of the materials. He shall place sufficient lights on or near the work, and keep them burning from twilight to sunrise; he shall observe such rules relative to signals and safeguards as the laws, regulations, or ordinances require; and shall also provide watchmen on the work for the protection of the public.

Liability of Contractor. The Contractor shall assume all liability for, and indemnify the company against, all loss, cost, or damages for or by reason of any liens, claims, or demands for materials; all loss from laborers, mechanics, and others; from any damages arising from injuries sustained by mechanics, laborers, or other persons, by reason of accidents or otherwise; and from damages sustained by depositing materials to public injury, or to the injury of any person or corporation (including costs and expenses of defense), provided that he be duly notified of the bringing of suits in such cases, and be permitted to defend the same by his own counsel, if he should so elect.

Other Work on the Company's Land. The Company reserves the right to carry on its construction and other work, outside that enumerated in this specification, at the same time that the Contractor is prosecuting the work under these specifications; and its Engineer shall at all times be authorized to permit others to pass over or haul any materials over the Company's land, and perform work thereon, having at all times due regard to the fact that such authority given to him shall not seriously interfere with or impede the work of the Contractor.

Cleaning up Débris. The Contractor shall remove all false-work, piling, and other unsightly material and obstructions, all débris and surplus materials from the site of the work, the right of way, adjacent properties, highways, and thoroughfares as each piece of work is completed. Channels of streams, public and private roads, and streets must be left in as good order as previous to the commencement of the work, and in a condition satisfactory to the Engineer and proper authorities.

INTERFERENCE WITH TRAVEL, ETC.

Obstruction to Travel. The Contractor shall conduct his work in such manner as neither to obstruct traffic on any railroad, highway, or thoroughfare, on land or water, nor interfere with, nor obstruct the use of private property, or wagon entrances, or the work of other contractors employed at the site of the work. In case of accident or claim for damages, due to the Contractor's neglect in these respects, he will be held strictly responsible for any such claim therefor.

Interference with Traffic. When work is to be done upon or adjacent to a railroad, the Contractor shall so prosecute his work as to interfere as little as possible with the traffic of such railroad; and all work that may affect the safety of the traffic of the same shall be subject to the direction of the superintendent of the railroad company upon which, or adjacent to which, the work is being carried out.

Where the work under this contract is crossed by public or private roads, the Contractor shall provide and maintain a safe road for traffic, and the work shall be carried on in such a manner as not to obstruct or block travel. Where directed by the Engineer, temporary crossings shall also be provided. All material excavated or delivered shall be so placed as not to interfere with traffic.

Watchmen and River Signals. The Contractor shall provide at his own expense the necessary watchmen, signals, and lights, and must observe the local laws of the district in protecting the public against all injury and damage. He shall conform to all the rules and laws governing navigation in the waters crossed by structures specified in this contract, and shall notify the proper authorities of the location of, or change in position of, proposed structures and plant in said waters, and shall establish and maintain the necessary lights, fog signals, etc., upon structures in course of construction, and upon his plant. In case of any damage resulting from neglect to keep and maintain suitable lights and

signals, or from mistake in signals, it must be promptly repaired at the expense of the Contractor.

Railroad Crossings. Where the work is to be constructed under the tracks of a steam railroad, the Contractor will be required to make satisfactory arrangements with the railroad company for the support of its tracks.

Water and Gas Pipes—Drainage. The Contractor is required to sling, shore up, and secure in their places all water and gas pipes and electrical conduits, or other underground structures encountered, without injury; and to provide for and maintain the flow of water, gas, electricity, drainage, and watercourses, whether on the surface or underground, which may be intercepted or interrupted during and by the progress of the work. Where the location of such pipes, drains, etc., has to be changed on account of the new construction or its appurtenances, the Contractor shall bear all expenses attending such changes.

Restoring Street and Road Surfaces. All road surfaces, sidewalks, and paving, disturbed by the work herein described, shall be restored to their original condition upon the completion of the work.

DAMAGES, CLAIMS, ALTERATIONS, ETC.

Damage to Persons and Property, Patents, etc. The Contractor shall be responsible for all damage to persons and to public and private property; for trespassing, or for any other offense committed by his workmen or others in his employ; for damage by explosives, fires, or any other causes incident to the conduct of the work. Any damage resulting from neglect of precautionary provisions by the Contractor or his employes, shall be paid for by the Contractor and, if necessary, the payments may be withheld, at the option of the Engineer, until such damage is satisfactorily settled. The intention of the contract is that the Company shall not be held responsible for any claims or losses incurred through the construction of the work herein described.

Suits, Claims, Patents. The Contractor shall indemnify the Company from all suits and actions of every nature and description brought against the said Company for, and on account of, the use of any patents or infringements of patents in connection with this contract, or for any damages or injuries received and sustained by any party or parties in the performance of the work under this agreement.

Forfeiture for Overtime—Liquidated Damages. It is expressly agreed that time is of the essence of this contract, and the Contractor agrees that the Engineer is authorized to deduct and

retain permanently out of the moneys which may be due or become due the said Contractor under this contract, the sum of.....dollars per day as *liquidated damages*, and not as a penalty, for each and every day that the work herein described remains uncompleted beyond the time stipulated.

NOTE.—This claim is seldom enforced as the Company may have to prove that it has been damaged to the amount specified and that such damage is entirely due to the delay of the Contractor in completing his work. Of course, the sympathy of the Engineer is often with the Contractor who is behind with his work, through no fault of his, and the sympathy of the jury is generally with the Contractor and workingman, as against the party with money, be it an individual or a corporation.

NOTE.—When the *penalty* for the noncompletion of work on time is provided in the contract, the amount of same may be recovered from the Contractor by legal process; but if the Contractor is delayed by the Company at any time during the progress of the work, the penalty cannot be enforced by the Company.

Should the Company order extra or additional work, for which extra time is allowed, it does not excuse the Contractor from completing the work on time nor from making the payment for delay.

Extra Work. The Contractor shall do any extra work, not herein otherwise provided for, when and as ordered in writing by the Engineer; and shall, when requested by the Engineer so to do, furnish itemized statements of cost of the work ordered; and give the Engineer access to accounts, bills, and vouchers relating thereto; nor shall any claims be allowed for extra work unless the same shall be done in pursuance of a written order from the Engineer, and the claim made at the first settlement after the work is executed; unless the Engineer, at his discretion, shall direct the claim, or such part of it as he may deem just and equitable, to be allowed; and it is expressly understood that the Contractor agrees to accept such allowances and estimates in full satisfaction of such extra work, loss, or damage, the decision of the Engineer as to the amount of such extra work, loss, and damage being as final, conclusive, and as binding on both parties as though the said extra work were a part of the work specifically described in this contract.

NOTE.—It is customary for the Engineer to allow from 10 to 15 per cent for profit over and above the actual cost of the work, which should include the cost of superintendence and repair of tools.

Alterations. The Engineer may from time to time, by an instrument in writing signed by him, order the Contractor to make changes in the work. In case the changes so ordered

make the work less expensive to the Contractor, a proper deduction shall be made from the contract price, and the Contractor shall have no claim, on this account, for damages or for anticipated profit on the work that is dispensed with; in case such changes make the work more expensive, a proper addition shall be made to the contract price; such deduction or addition shall be determined by the Engineer. In case of any change ordered as aforesaid, or in case any other changes in the work are made by the mutual consent of the parties hereto, whether affecting the contract price or not, or the time of completion or not, all and each of the other provisions of this specification shall remain in force and apply to the contract as thus altered. Changes so made shall not make void any bonds that may have been given by the Contractor.

Change of Line and Grade. The line of the work or the gradients or elevations may be changed, if the Engineer shall consider such change necessary or expedient, and for any considerable alteration the injury or advantage to the Contractor will be estimated, and such allowance or deduction made in the price as the Engineer may deem just and equitable; but no claim for an increase in prices on the part of the Contractor will be allowed or considered unless presented in writing to the Engineer before the work on that part of the section where the alteration is to be made shall have been commenced.

NOTE.—This provision is, of course, applicable to railroads, pipe lines, canals, sewers, etc., and hence is not, strictly speaking, a general provision; but, as it applies to many kinds of work, it has been introduced here.

NOTE.—The changing of plans and specifications is always to be avoided, if possible, but it is almost impossible to write a faultless contract and to foresee all conditions that will arise. After the beginning of construction, changes must sometimes be made. The right of the Engineer to make changes during the progress of the construction, while customary, should generally be limited to details and to the character of the materials. Of course, the more perfect the plans and specifications, the fewer alterations will be required, and, consequently, the fewer demands for extra compensation for unforeseen work. Remember that changes made in the specification, plans, or contract after execution are not binding unless they are known and agreed to by both parties to the contract, in which case all should be noted in writing on the instrument and signed by both parties setting forth the date of the change. All changes on drawings should be made in a conspicuous color and be carefully dated.

PAYMENT, LIENS, ESTIMATE, BOND, ETC.

Spirit of Specification. The "spirit" of these specifications is to furnish all material and workmanship necessary for the construction herein described, complete in every respect, for

the purpose for which it is designed; and the Contractor is hereby bound to consider and provide for any workmanship or materials, which are obviously necessary in order to carry out the full intent and meaning of the plans, details, diagrams, and specifications, although the same may not be either directly or indirectly noted by drawings or specifications. He shall provide, in his proposal, for the said omissions, as fully as though they were specifically denoted, and shall execute the same without charge or claim therefor.

Payment. Monthly estimates of the amount of work done and material delivered under this contract shall be made by the Engineer on or about the first day of the month; and from the estimates so made, the value of the work done and of the material delivered on the site of the work shall be determined. Upon the Contractor's furnishing a complete release of liens for all labor and material furnished to the time of the taking of the said estimate, within.....days the Company shall pay the Contractor.....per cent of the amount due, as determined by the Engineer, and this method of payment shall continue until the work under this contract is completed.

The balance or amount remaining unpaid and due the Contractor shall be paid within.....days after the final completion and acceptance of the work by the Engineer.

NOTE.—*Amount of Retained Percentage.* To insure completion, it is customary to retain from 10 to 20 per cent of the monthly estimate until the work is finished. In very large contracts, as certain sections are completed and turned over to the Company, the retained percentage is surrendered to the Contractor. The time required in making up estimates, forwarding same to headquarters, auditing, and forwarding check, takes from 10 to 30 days, depending on circumstances; 15 days is usually ample time to allow for these transactions.

NOTE.—*No Claim for Payment until Work is Turned Over.* The Contractor can make no claim for payment until the materials or the work accomplished have been put into the possession of the Company. Should the Company decline to accept the materials or work after same has been turned over to it, the Contractor may then bring suit to compel payment.

NOTE.—*No Payment until Certain Amount Complete.* Payment may be made by installments based on a certain amount accomplished. Under such an arrangement the Contractor can make no claim for payment until such an amount has been accomplished. Should the Contractor abandon the work before such an amount of work be done, he could not recover.

NOTE.—*Accidents.* When the work is to be finished before payment is made, the Contractor must stand the risk of fire, flood, or other accident; but if there is no written contract or custom requiring the entire construction to be completed before payment is made, the Contractor may recover for what he has

accomplished, in case of accident, fire, or flood, provided it can be proved that he used all proper precautions.

Some contracts require the Contractor to procure and present certificates of the proper fulfillment of contract from the Engineer, Inspector, etc., before claim is made for payment.

Release of Liens. Before the final payment the Contractor shall give the Company a complete release of liens and claims chargeable to said Contractor; and if at any time any liens or claims are filed, making the Company, or the work, or construction liable, the Company has the right to retain out of any and all payments due, or to become due to said Contractor, amounts sufficient completely to indemnify the Company, work, or buildings, against such liens and claims; and in the event of any liens, or claims, being established after all payments have been made and the security surrendered to the Contractor, the Contractor is to pay back to the said Company all money or moneys that the Company may have been compelled to pay in consequence of such liens or claims.

NOTE.—It is of the greatest importance that the Company be protected against liens of every character. In cases of unsuccessful contractors, it will be found that laborers, mechanics, and material men will make use of liens to protect themselves.

Liens. The Contractor shall file no liens for any labor or material furnished under this contract; such waiver of liens, however, shall in no way be considered as a waiver of action by law for the recovery of the amount due the Contractor as approved or awarded by the Engineer; it is further agreed that no subcontractor for work or material and no laborer, mechanic, or any person whatsoever shall have the right to file any lien of any kind for any sum which may be due or become due to him under this contract, or for work and material furnished thereunder, or for any other purpose, and his right to file such liens is expressly waived.

Monthly Estimate Subject to Variation. Every monthly estimate shall, for the time being, be conclusive upon both parties thereto, but being made (except as herein provided as to extra work) merely as a basis for payment on account, though with a great desire and effort for accuracy, may be only approximately correct, and therefore shall (except as herein provided as to extra work) be subject to correction by the Engineer in any subsequent monthly estimate, or in any final estimate. No such monthly estimate or certificate for unfinished work shall be considered or taken as an acceptance of the work; or as a release of the Contractor from responsibility therefor; or as controlling

the Engineer in the final certificate, which alone shall operate as an acceptance of the work or as a release of the Contractor.

Contractor's Bills in Arrears. If at any time it shall be found that the Contractor's bills for material or labor are not being paid within a reasonable time, the Company may withhold from the Contractor's monthly estimate a sufficient amount to cover the said bills, and the Company shall apply the amount so withheld to the payment of said debts.

Abandonment or Violation of Contract. Should the Contractor neglect or abandon the work, or should the Engineer at any time be convinced that the work is unreasonably delayed, or that the conditions of the contract are being wilfully violated, or executed carelessly, or in bad faith, he may notify the Contractor in writing and, if his notification be without effect within 24 hours after the delivery thereof, then and in that case the Contractor shall discontinue all work under the contract, and the Engineer shall have full authority and power immediately to enter upon and take possession of the work, plant, tools, and materials; and to purchase and hire materials, tools, labor, animals, and machinery for the completion of the contract at the expense of the Contractor, or his sureties, or both; or the said Engineer may declare the contract null and void, in which case the security bond, the retained percentage, the materials built into the work, and the materials delivered shall then become the property of the Company.

In case either of the above methods is resorted to, the Company shall have the right to use the plant, animals, and materials until the completion of the work; and should the amount retained on the previous estimates be insufficient to pay all bills in connection with the work, the Company shall have the right to sell as much of the Contractor's plant and tools as shall be sufficient to make good the deficit. Upon the completion of the work the plant and tools, or those that may remain in case it is necessary to make such sale, shall be turned over to the Contractor.

Right to Suspend Work. The Engineer reserves the right to suspend or terminate the work embraced in these specifications for reasons not herein specified, and the Contractor shall discontinue all work within 10 days after receiving notice of such suspension or termination; in which case, the Contractor shall be entitled to payment in full for all materials actually handled or supplied, at a valuation to be fixed by the Engineer, but shall make no claim for consequential damages or anticipated profits upon work not actually performed, or damage of any kind resulting from such suspension or termination.

Agreement. The successful bidder, upon notice from the Company, shall at once furnish it with the names of the sureties to be offered, and shall execute the agreement and furnish the executed bond within.....days from the date of mailing of notice to the said bidder that the contract is ready for signature; and in case of failure or neglect to do so, he will be considered to have abandoned the contract, and the check accompanying the proposal shall be forfeited to the Company.

Bond. The Contractor will be required to give an approved surety company bond to the Company in the sum of..... .....dollars for the faithful execution of the work under this specification; for keeping in perfect repair and good order all of the new work constructed hereunder; for all breakage or other damage that may occur to any works that may be within the lines of the work herein described, for..... .....years after date of final payment; for the prompt payment for labor and materials used in the work; and for the protection of the Company from all claims on patents, or damages to persons or property caused by the negligence of the Contractor or his employes in connection with the work herein described; and it is understood that such surety shall not in anywise be released by any modification or alteration in this contract agreed upon between the parties, the said bond being expressly subject to said modifications or alterations. Said bond shall be surrendered.....months after the date of completion and acceptance of the work executed hereunder.

NOTE.—Avoid personal bonds; good trust company bonds are secured readily by good contractors and are much more satisfactory to the Company.

TYPICAL ILLUSTRATIVE SPECIFICATIONS

The various groups of clauses which have just been given under the head of General Provisions are, as the heading indicates, intended to cover the general features of any well-drawn set of specifications. The typical specifications which follow give a clear idea of the nature of the provisions required for special kinds of work, the selections being sufficiently varied in character to cover the usual types of contract.

RAILROAD GRADING

Tools, Materials, and Labor. The Contractor shall, at his own expense, cost, and charge, find and provide a full and ample supply of the best and most suitable tools and appliances required

to be used in the performance of the work to be executed under this contract; he shall provide the best materials of every kind that may be needed for the thorough and expeditious execution of said work; and he shall furnish and provide in sufficient numbers all mechanics, laborers, and other workmen, and also all things that may be requisite and necessary for constructing and completing, within the time herein stipulated, the whole of the work herein agreed to be done.

Location of Work. The work covered by this specification is on the line of the.....Railroad which is located between.....in.....County and .....in.....County, all lying in the State of..... The section extends from Station..... .....to Station..... and involves principally clearing, grubbing, grading, trestling, masonry, pipe, masonry or timber culverts.

GRADING SPECIFICATIONS

Under this head shall be included all the clearing and grubbing, all excavation and embankment required for the formation of the roadbed ready for the track; cutting of ditches or drains about or contiguous to the road; widening or changing channels for streams or watercourses; the construction of farm crossings; the foundation of culverts and bridge masonry, walls or bridges; reconstruction of mill races, highways, and roads where they are interfered with or destroyed in the formation of the roadway; also the furnishing and erecting of all masonry, trestling, planking, piling, pumping, bailing, and all the excavation and embankment in any way connected with or incident to the construction of said railroad.

The road shall be graded in conformity with such directions as the Chief Engineer may give concerning breadths, depths, and slopes of excavation and embankment.

Clearing. The lands of the railroad company shall be cleared to the full extent of the right of way of all trees, logs, bushes, and other perishable matter, which shall be destroyed by burning, or deposited in heaps, as the Engineer may direct. Large trees must be cut not more than 1 foot from the ground and, under embankments less than 4 feet high, they shall be cut even with the surface of the ground. The top of stumps shall not be less than 3 feet below subgrade under embankments. All small trees and bushes shall be cut even with the ground. The burning of brush must be done in such a manner as not to endanger adjacent timber land or property. Clearing shall be paid for by the acre

or fraction thereof, to the extent indicated by the Engineer by stakes or by marks on the ground or timber. All trees which the Engineer may reserve shall be stripped of their tops and branches, cut to such lengths, and be neatly piled at such places, on the right of way, as the Engineer may direct.

Grubbing. All stumps, roots, muck, and perishable material shall be grubbed out and removed from all places where embankments occur less than 2 feet in height. All stumps grubbed out shall be burned. Until the Contractor is notified that the work done on the surface to be grubbed is satisfactory to the Engineer, no embankment shall be made on such surface. Grubbing is to be paid for by the acre or fraction thereof actually grubbed.

Excavation. All material shall be measured in the excavations, and estimated by the cubic yard, and shall be classified under the following heads, viz: solid rock, loose rock, earth, foundation excavation in water, and ditching in earth.

Solid Rock. Solid rock shall include all rock which will ring under the hammer, which is found in ledges and detached masses exceeding 1 cubic yard each; and which, in the judgment of the Engineer, may be best removed by blasting.

Loose Rock. Loose rock shall include all kinds of hard shale, slate, soapstone, detached stones of less than 1 cubic yard and more than 3 cubic feet, and all rock which, in the judgment of the Engineer, cannot be plowed and which can be removed with pick and bar, and is soft and loose enough to be removed without blasting, although blasting may be resorted to in order to facilitate the work.

Earth. Earth shall include clay, sand, loam, gravel, and all other matter of an earthy nature, of whatsoever name or character, not unquestionably rock as above defined. Boulders or detached stones containing less than 3 cubic feet shall be classified as earth.

Excavation in Water for Bridge or Culvert Foundation. Foundation excavation in water shall apply to material below the natural water surface and only in cases where (through no fault or delay of the Contractor) constant unavoidable pumping or bailing is a necessity, and where draining by a ditch would be too expensive or impossible; the material shall be classified as excavation, and the price shall include the necessary cofferdams, caissons, sheeting, shoring, draining, bailing, and pumping of water, and the benching and dressing of the rock for base of masonry. Where unnecessary delay occurs in finishing a foundation promptly in dry weather, it will be at the Contractor's risk, as regards the excavation, in case water is met.

Embankments. Embankments shall generally be made in horizontal layers, crowned in the middle, in accordance with the instructions of the Engineer, and shall consist of materials which, in his judgment, are suitable; they shall be built of such width and carried to such height above grade as the Engineer may deem necessary to provide for shrinkage, compression, washing, drainage, and settlement, and must be maintained to their proper height, width, and shape until accepted by the Engineer. No large stone will be allowed within a depth of at least 2 feet below grade; the best materials must in all cases be reserved for finishing and dressing the surfaces. Whenever the embankment is made from the side ditches, such ditching and the crest of the slopes thereof shall in no case approach within 6 feet of the foot of the embankment slopes, and the slopes of such ditching next to the embankment shall not be steeper than the slope of the embankment. Whenever new watercourses or channels are required to be formed, they shall be put at such distances from the foot of the slopes as the Engineer may direct.

No perishable materials will be allowed in embankments. All proper materials taken from the excavation on the line of the railroad shall be placed in the embankment, and all surplus materials shall be used in widening embankments in such manner as the Engineer may direct.

The subgrade must be compact and finished to agree with the standard roadbed section, and no depression that would hold water shall be left.

Embankments about Culverts. Embankments about masonry and pipe culverts and bridges shall be built at such times, and in such manner, and of such material as the Engineer may direct. Embankments shall be carried forward in the usual way to within 10 feet of any bridge or culvert, finished or in progress, from which point the earth shall be carefully rammed to such width, depth, slopes, and in such manner as the Engineer may direct. No additional prices shall be allowed for this work.

Borrow Pits and Spoil Banks. In all cases where the excavations are insufficient to make the embankments, the deficiency shall be supplied by widening the excavations, or it shall be supplied from borrow pits, as the Engineer may direct, and all such excavations and borrow pits shall be located, drained, and sloped as the Engineer may direct. No borrow pit shall be opened until same has been staked out on the ground by the Engineer in charge. All excavations and borrow pits shall be left in such shape that they can be readily measured.

Any surplus material taken from the excavation and not required for embankments, or other purposes, shall be deposited

evenly on either side of the embankment, as the Engineer may direct, and shall in no case be raised above the grade of the road.

Ditches. In cuts, ditches shall be dug along the foot of the slopes, of such dimensions as the Engineer may direct. To protect the cuts from washing, intercepting ditches shall be dug above the cutting, upon ground sloping toward the cuts, and connected with the embankment ditches, when directed by the Engineer; and if the material from such ditches is wasted, it shall be deposited between the ditch and the cut. Such excavation shall be paid for as part of the ordinary excavation of the section.

Ditches for changing the flow of streams and for draining marshes, ponds, etc., shall be cut of such dimensions and the materials shall be so deposited as the Engineer shall direct; the same to be paid for at the price named in the proposal for "Ditching in Earth".

Valuable Material and Timber. All materials taken from the excavations, which, in the judgment of the Engineer, may be of greater value to the railroad company for other purposes than embankments, and also all timber, removed from the line of the railroad, shall be considered the property of the Railroad Company, and shall be deposited in convenient positions, under the direction of the Engineer.

Slips and Falls. All slips and falls of slopes attributable, in the opinion of the Engineer, to excessive use of powder, negligence, or carelessness of the Contractor shall be removed by the Contractor at his own cost; but if not so attributable, an allowance, to be fixed by the Engineer, shall be made for such removal as "Earth Excavation".

Measurements. Clearing shall be paid for by the acre or fraction thereof. The clearing of scattered trees shall be paid for by the approximate area of the surface of ground covered by their branches before being felled. Grubbing shall be paid for by the acre or fraction thereof, of surface actually grubbed. The Contractor shall give the Engineer at least 48 hours' notice previous to beginning the making of embankments on surface grubbed, and the same shall not be paid for unless it shall have been measured by the Engineer, and the Contractor shall have been given a written order to proceed with the embankment on the surface in question.

Materials in excavations shall be measured whenever possible, and the term "excavation" shall include all cuttings, borrow pits, roadways, changes of watercourses, ditches, foundations, and trestle pits, and, in fact, every kind of excavation required at any time in the course of the work.

Excavation, in all the several classes thereof, shall be of such dimensions and slope as the Engineer may direct, and shall be estimated and paid for by the cubic yard, and no allowance whatever shall be made for overhaul. The price for excavation shall include all the necessary sheeting, shoring, pumping, and bailing. For the material to be excavated (under the.....Railroad from.....Station to.....Station) for the roadbed and for abutment walls, a special price will be paid, as named in the proposal, which price for excavation shall cover the sheathing of excavation and supporting of tracks in a manner satisfactory to the Chief Engineer of the.....Railroad Company.

GENERAL CONDITIONS AND PROVISIONS

Duties of Contractor. Contractors shall satisfy themselves by a careful personal examination of the nature and location of the work they bid for, of the general form of the surface of the ground, and all other matters which can in any way influence their contract; and no information upon such matters derived from the maps, plans, profiles, drawings, or specifications, or from the Engineer or his assistants, shall in any way relieve the Contractor from any risk, or from fulfilling any of the terms of this agreement.

Interference with Traffic. When work is to be done upon or adjacent to a public or private road, or to a line of railway in use, the Contractor shall so prosecute his work as to interfere as little as possible with the traffic of the railway, or the traffic of such public or private road. And all work that may affect the safety of the railway traffic shall be subject to the direction of the Division Superintendent of the railway company. When it is necessary to support the tracks of the railway, the railway company will furnish and place all of the necessary timbers for this work, but the Contractor shall do all the excavating therefor.

Property on Right of Way. Fences, buildings, timber, and wood on the right of way along the line of the road are the property of either the landowner, or the party of the ..... part; and if not removed by the landowner within a reasonable time, shall be cleared off by the Contractor, and shall be piled up, and preserved for the use of the party of the ..... part, without charge.

Damages. In case one portion of the work, contracted to be done in accordance with these specifications, is delayed through the negligence or incompetence of a contractor for some other

portion of the work, whatever damage may result, or whatever expense may be incurred by the Contractor so delayed, because of such negligence or incompetence, the amount of damage or expense shall be charged to the contractor at fault, and the Engineer shall decide the amount so to be charged; and the party of the second part shall in no wise be responsible therefor, or for the payment therefor by the other contractor.

Roads to be Opened. Contractors having work awarded to them shall, immediately after signing their contracts, proceed to open and maintain such good and safe roads and paths for foot or horse travel along the whole line of their sections, as may be directed by the Engineer; and on portions of the line where there are no highways convenient for the wagoning of supplies, they must open and maintain such roads, and the Engineer shall decide what extra amount, if any, they will be entitled to for this work.

Any person having permission from the Engineer shall be allowed to pass along or haul any materials required for the road over any section, provided such persons do not interfere with or impede the work of the Contractor.

Marks and Stakes to be Preserved. Contractors shall carefully preserve bench marks and stakes and, in case of willful or careless neglect of these, they shall be charged whatever the Engineer shall consider an equitable amount to cover damages arising from such negligence.

All excavations and embankments shall conform to the line and stakes set out by the Engineer, and any excess of excavation or waste of material required for embankment at the mouth of cuts, due to neglect of these lines and stakes, shall not be estimated or paid for.

Contractors shall clear away the surplus stone and wreckage from masonry sites after the jobs are done; and, before the completion of each section, remove from adjacent properties, berms, and highways the blasted rock and all other débris accumulated during construction.

Grade. The word "grade" whenever herein used refers to the surface of the roadbed as completed and prepared for the reception of the ballast.

Acknowledgment. These specifications are hereby acknowledged, accepted, and made part of this agreement.

Claims for Labor or Material. It is hereby agreed that no lien nor claim shall be filed by anyone for the work or labor to be done or the materials to be furnished, under or in pursuance of this contract.

FOUNDATIONS

General Specifications. Foundations for masonry shall be excavated to such depths as may be necessary to secure a bearing which is satisfactory to the Engineer. In case of foundations in rock, the rock shall be excavated to such depths and in such form as may be required by the Engineer, and shall be dressed approximately level to receive the foundation course. Materials excavated shall be paid for as provided for under "Excavation".

Special Foundations. Should the bottom as found be not satisfactory, special foundations shall be constructed of concrete, reinforced concrete, or of timber piling or platforms, as directed, and in accordance with plans to be furnished. If work of special character be required, the Contractor shall be paid for it at the special prices named in the proposal, and said prices shall include all materials and all labor necessary for placing it in the work.

Piles. Piles shall be of white oak, long-leaf yellow pine, or spruce pine, as directed; sound, of straight growth, not less than 8 inches in diameter at the small end, and not less than 12 inches at the butt end when sawed off. They shall be trimmed close, barked if required, pointed or shod as directed, and hooped to prevent splitting. They shall each be of one piece without splicing or doweling. They shall be driven with a hammer weighing at least 2500 pounds, to refusal, or to the point directed, in straight rows, and shall be sawed off truly level. If any piles are raised by the subsequent driving of others, they shall be re-driven. If any piles be driven too low to be cut off or fitted at the required elevation, proper piles shall be substituted. Piles split or otherwise injured shall be replaced or repaired as directed.

The piles in place shall be paid for at the price per lineal foot given in the proposal. No part of the pile shall be paid for except that which remains in the work.

Pile Shoes. Pile shoes, when required, shall be paid for as additional steel. They shall be chilled points, 4 inches square at the point of the pile, with 4 straps of approved size, fastened with 8 three-eighths-inch by 4-inch spikes to the pile, which shall be properly fitted to give a square and even bearing on the shoe.

MASONRY

GENERAL CLAUSES

Stone, General. Stone masonry shall be built of the kinds of stone specially designated, with such arrangement of courses and bonds as is directed or shown on the plans. The stone shall be hard and durable, as large as practicable for the work, of approved quality and shape, and in no case having less bed than rise.

Laying. Stone masonry shall be laid with the stones on their broadest beds, well bonded and solidly bedded.

All walls shall be laid up in cement mortar, cement grout being used to fill all vertical joints which cannot be thoroughly filled with mortar, and the stone shall be thoroughly wetted when it is laid. All walls shall be made as water-tight as possible. The face and back of the walls shall be carried up together. No hammering on the wall shall be allowed after the stone is set; if any inequalities occur, they shall be carefully pointed off.

Clean Walls. The showing face of all walls shall be left thoroughly clean upon the completion of the work.

Setting. Dressed stone shall be set with a lewis if required; and where dressed stone is bedded in mortar it shall be settled on the bed with a wooden maul.

Concrete Coping. Concrete coping shall be composed of 1-3-6 concrete as specified, built to the dimensions shown on the plans. The top and sides shall be treated as specified under the paragraphs relating to exposed surfaces of concrete. If made as a monolith on top of the wall, the coping shall be cut into such lengths as may be directed. Payment shall be made at the price per cubic yard for "Concrete Coping" in the proposal, which price shall include the cost of all forms, etc.

Concrete coping may be made as an artificial stone. If so made, the length of the blocks and all details shall be approved by the Engineer.

Back Walls. Where stone is used for back walls, it shall be laid as stretchers and extend through the wall without being backed with other masonry; the faces shall be rough-pointed. Back walls shall be capped with a regular course, peen-hammered on top. Generally, they shall not be built until the superstructure has been placed in position.

Bridge Seats and Pedestal Blocks. Where bridge seats and pedestal blocks are of stone, approved granite shall be used. The top surfaces under the bearings of trusses, main girders, columns, or other principal metal bearings shall be bushhammered and the remainder of the upper surfaces shall be peen-hammered. The showing edges of bridge seats, pedestals, and caps shall be rough-pointed. Bushhammers shall have 5 cuts per inch.

Concrete Bridge Seats and Pedestal Blocks. Where bridge seats and pedestal blocks are of concrete, they shall be composed of 1-2-4 concrete, made with three-fourths-inch stone, as specified, and built to the dimensions shown on the plans, with a hard trowel finish on all showing faces. Payment shall be made at the

special price per cubic yard named in the proposal, which price shall include the cost of all forms, etc.

Finish of Walls not Coped. The top of the masonry when not covered by a coping shall be finished with large stones selected for the purpose, which will give an approximately flat surface.

Pointing. The joints on faces of masonry above the foundation shall be cleaned out to a depth of 1 inch, wetted, and pointed with Portland cement mortar well and securely pressed into the joints; the whole work shall have a neat and clean finish. Cut-stone work shall be hollow-pointed; all other masonry shall be cut-pointed.

New Masonry on Old. When new masonry is laid on old masonry, the latter shall be cleaned, wetted, and thoroughly grouted before laying new work. All new work shall bond with the old. The new face stones shall match the old.

Dressing before Setting. All cutting and dressing necessary shall be done before the stones are set, and by skilled workmen. Under no circumstances shall the hammering or dressing of stone upon the walls be allowed. The stones shall be placed in position so as not to disturb those previously laid.

Dressing. In all classes of work, the faces of the stone shall have uniform projections, not exceeding 3 inches beyond the neat lines. All projecting angles and arrises shall have hammer-dressed beds and joints and shall be run with a neat chisel draft of $1\frac{1}{2}$ inches on each face.

Mortar Joints. Mortar joints in the face of the wall, in first-class and second-class work, shall not exceed one-half inch in thickness. The vertical joints of the face shall be in contact at least 1 foot in first-class and 9 inches in second-class work, measured in from the face, and as much more as the stone will admit.

Dashing Backs of Walls. The joints on the back of all masonry walls shall be carefully and thoroughly dashed with cement mortar so as to make the walls as nearly water-tight as possible.

When the back of a wall adjoins rock, it shall be built tight against the rock and the joint shall be thoroughly grouted.

Dry Stone Packing. Dry stone packing shall consist of stone laid without mortar, and the stone used shall generally be from three-fourths of a cubic foot to 2 cubic feet in volume.

Measurement. All masonry shall be built according to the plans and instructions furnished by the Engineer, and the several classes thereof shall be estimated and paid for by the cubic yard, computing only the actual solidity thereof required by the plans.

No constructive or conventional measurement shall be allowed, any rule or custom to the contrary notwithstanding.

Freezing Weather. All work in stone and brick masonry and concrete shall be suspended during freezing weather except on structures in which delay would affect the general progress of the work and under such regulations and conditions as the Engineer may prescribe. Whenever required by the Engineer, the sand and water shall be heated before being used in the work. No masonry laid in freezing weather shall be pointed until spring.

Inspection. All material shall be subject to inspection and any that has been condemned shall immediately be removed from the site of the work. All masonry shall be subject to the supervision of an Inspector whose duties shall be to see that the requirements of these specifications are conformed to, but his presence is in no way to be presumed to lessen in any degree the responsibility of the Contractor or his obligations.

No masonry of any kind shall be covered up before it has been inspected and passed upon.

Price to Include. The price per cubic yard paid for stone, brick, or concrete masonry shall include the furnishing of all material, all scaffolding, forms, and centering, and all other expenses necessary to the construction and completion of the masonry and the maintenance of same until the work is accepted.

CLASSIFICATION OF MASONRY

Masonry shall be classified under the following heads: First Class; Second Class; Third Class; First-Class Arch; Brick; and Concrete.

First-Class Masonry

First-class masonry shall consist of range rock work of the best description. The face stones shall be accurately squared, pointed, and bedded, and laid in regular and horizontal courses of not less than 12 inches in thickness and not greater than 30 inches, decreasing in thickness regularly from the bottom to the top of the walls. The stones of each course shall be so arranged as to form a proper bond with the stones of the underlying courses, and a bond of less than 1 foot shall in no case be allowed.

Stretchers. Stretchers shall not be less than 4 feet in length. They shall have 18 inches width of bed for all courses under 18 inches; and for all courses above 18 inches they shall have as much bed as face. They shall not break joint on headers.

Headers. Headers shall not be less than 4 feet in length. They shall occupy one-fifth of the face of the wall and no header shall have less than 18 inches width of face; where the course

exceeds 18 inches in height, the width of face shall not be less than the height of the course.

When the walls do not exceed 4 feet in thickness, the headers shall run entirely through, and in all cases they shall be long enough to form a proper bond with the backing.

When the stone used in any work is in very large blocks, exceeding the requirements given above, then a stone that runs into the wall to a distance at least as great as the average length of the stretchers shall be considered a header.

Backing. The backings shall be of third-class masonry or 1-3-6 concrete, as shall be directed by the Engineer, well bonded with the facework and itself.

Foundation Courses. All work below the neat line shall be 1-3-6 concrete, laid as specified, and paid for at the price for "1-3-6 concrete masonry in foundation".

Laying. The masonry shall be laid up as specified under "Laying".

Bridge Piers. Bridge piers built in streams subject to ice floes shall be built of *first-class masonry* facing with *concrete masonry* backing, in the heart of the wall.

The stones forming the cutwater of piers which act as ice breakers shall be neatly and smoothly dressed on their faces, and fastened together with iron cramps and to the interior of the piers. The surfaces of the other face stones shall, with the exception of the draft, be left as they come from the quarry unless the projection above the draft exceeds 3 inches, in which case they shall be roughly scabbled down to that projection.

Second-Class Masonry

Second-class masonry shall consist of broken or random range rock work of the best description, and shall conform in every other respect to first-class masonry.

Third-Class Masonry

Third-class masonry shall be formed of approved quarry stone of good shape and good flat beds. No stones shall be used in the face of the walls less than 6 inches thick, or less than 12 inches in their least horizontal dimensions.

Headers and Face Stones. Headers shall generally form at least one-fifth of the faces and backs of the walls, with a similar proportion throughout the mass when they do not interlock, and the face stones shall be well scabbled or otherwise worked so that they may be set close, and chinking with small stones be avoided.

Size of Stones, etc. In walls 5 feet thick or less, the stones used shall average from 6 to 8 cubic feet in volume, and the length of the headers shall be equal to two-thirds of the thickness of the wall; in walls over 5 feet in thickness, the stones used shall average 12 cubic feet in volume, and the headers shall not be less than 4 feet long. Generally no stones shall be used having a less volume than 4 cubic feet, except for filling the interstices between the larger stones.

Limit of Height and Bond. In no case shall stones be used having a greater height or build than 30 inches, and these stones must bond the joints above and below at least 18 inches; in all other cases the smaller stones used must bond the joints above and below at least 10 inches.

Foundation Stones. The stones in the foundation generally shall be not less than 10 inches in thickness and contain not less than 10 square feet of surface.

The foundation shall consist of 1-3-6 concrete, if so directed by the Engineer.

Laying. The masonry shall be laid up as specified under "Laying".

First-Class Arch Masonry

First-class arch masonry shall be laid in cement mortar, and shall be built in accordance with the specifications for first-class masonry, when and to the extent that the Engineer may direct. The ring stones shall be dressed to such size and shape as the Engineer may determine.

Ring Stones and Arch-Sheeting Stones. The ring stones and arch-sheeting stones shall not be of less thickness than 10 inches on the intrados of the arch, and shall be dressed with $\frac{3}{8}$-inch radial joints, and shall be of the full depth specified by plans, or otherwise, for the thickness of the arch. The joints shall be made on true radial lines, and the ends of the sheeting stones and the ring stones shall be dressed to make close joints. The ring stones and the arch-sheeting stones shall break joints not less than 1 foot apart.

Parapets. The parapets shall be finished with a coping course of the full width of the top of the parapet, with such projection as may be directed by the Engineer. The stones shall be not less than 10 inches in thickness.

Brick Masonry

Brick masonry shall be laid with the best quality of hard burned brick, well tempered and molded to standard size.

Quality of Bricks. No bats, except necessarily as closers for properly dimensioning the several courses, nor cracked, crooked, or salmon bricks, shall, under any circumstances, be allowed in the work. The bricks shall be thoroughly wetted and shall be laid, end and side at one operation, in full close joints of mortar. The style of bond shall be prescribed by the Engineer. The best-shaped and best-colored brick shall be reserved for facework, which shall be finished with a neatly drawn joint and pointed where required.

Mortar and Grouting. *Proportions.* All mortar to be used in the building of stone or brick masonry shall be composed of 1 part of cement to 3 parts of sand. All mortar for pointing and bedding copings, bridge seats, and pedestal blocks shall be composed of 1 part of cement to 2 parts of sand.

Grout shall be composed of 1 part of Portland cement to 3 parts of sand, except where the foundations are wet, when the quantity of sand shall be diminished, making the proportions 1 part of cement to 2 parts of sand, and this shall be used in the foundation masonry up to the neat lines, if required.

All the above mixtures shall be proportioned by measurement. It is assumed that 376 pounds of cement shall have a volume of 3.6 cubic feet. The sand and cement shall first be mixed dry in suitable tight boxes, after which the proper amount of water shall be gradually added. Only such quantities of mortar or grouting shall be mixed as are needed for immediate use; if allowed to set, it shall not be retempered and used in masonry construction.

Tensile Strength. Mortar taken from the mixing box and molded into briquettes, 1 square inch in cross section, shall develop the following ultimate tensile strengths:

	Per Square Inch
7 days (1 day in air, 6 days in water), 1 part of cement to 3 parts of sand.....	125 lbs.
28 days (1 day in air, 27 days in water), 1 part of cement to 3 parts sand.....	175 lbs.

Sand. Sand for grouting shall be tide-washed, sharp, siliceous, dry-screened bar or approved bank sand, containing not more than 5 per cent of loam, clay, dirt, or other impurities. Sand for mortar shall be composed of grains graded from coarse to fine, thoroughly screened to reject all particles exceeding one-eighth inch in diameter, and shall be clean and sharp, containing not more than 5 per cent by weight of clay, loam, dirt and other impurities, and equal in quality to the best New Jersey bank sand.

Water. Water shall be fresh, and free from dirt, oil, or grease. Salt water may be used, as directed by the Engineer, when necessary to construct masonry in freezing weather.

Cement

Kind. All cement shall be Portland, of the best quality, dry and free from lumps. By Portland cement is meant the finely-pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials to which no addition greater than 3 per cent has been made subsequent to calcination.

Packages. Cement shall be packed in strong cloth or canvas bags, or in sound barrels lined with paper, which shall be plainly marked with the brand and name of the manufacturer. Bags shall contain 94 pounds net and barrels shall contain 376 pounds net.

Inspection. All cement shall be inspected. The Contractor shall submit the cement, and afford every facility for inspection and testing, at least 12 days before desiring to use it. The Engineer shall be notified at once upon receipt of each shipment. No cement shall be inspected or allowed to be used unless delivered in suitable packages, properly branded.

Protection. The cement shall be protected in a suitable building having a wooden floor or platform raised from the ground, and may be reinspected at any time.

Storage. The cement shall be stored in a manner that will enable each carload lot to be kept separate and be tagged with car number and date of receipt. One carload shall not be placed immediately upon another.

Failure of Brand. The failure of a shipment of cement on any work to meet the requirements given below may prohibit further use of the same brand on that work. Rejected cement shall immediately be removed from the work.

Quality. The acceptance or rejection of a cement to be used shall rest with the Engineer, and shall be based on the following requirements:

Specific Gravity: not less than 3.1.
Ultimate Tensile Strength per square inch:

7 days (1 day in air, 6 days in water)	500 lbs.
28 days (1 day in air, 27 days in water)	600 lbs.
7 days (1 day in air, 6 days in water), 1 part of cement to 3 parts standard quartz sand	200 lbs.

28 days (1 day in air, 27 days in water), 1 part of cement to 3 parts standard quartz sand ..... 275 lbs.

Fineness: Residue on No. 100 sieve not over 8 per cent by weight. Residue on No. 200 sieve not over 25 per cent by weight.

Set. It shall require at least 30 minutes to develop initial set, and not less than 1 hour nor more than 10 hours to develop hard set. These requirements may be modified where the conditions of use make it desirable.

Constancy of Volume. Pats of cement 3 inches in diameter, one-half inch thick at center, and tapering to a thin edge, when immersed in water after 24 hours in moist air, shall show no signs of cracking, distortion, or disintegration. Similar pats in air shall also remain sound and hard. The cement shall pass such accelerated tests as the Engineer may determine.

The following test will be made in accordance with the rules adopted for Standard tests by the American Society for Testing Materials, August 16, 1909, with subsequent amendments.

Sulphuric anhydride (SO_3); not more than 1.75 per cent.

Magnesia (MgO); not more than 4 per cent.

Briquettes for testing shall be 1 square inch in area of cross section; sieves shall be of brass wire-cloth having approximately 9800 and 37,500 meshes per square inch, respectively, the diameter of the wire being 0.0045 and 0.0023 inches, respectively.

Concrete

Proportions. Concrete masonry shall consist of two grades. These shall be used wherever specified or directed by the Engineer. They shall be known as 1-2-4 and 1-3-6, respectively.

Parts by Volume

CEMENT	SAND	STONE
1	2	4
1	3	6

If required by the Engineer, the mixture shall be modified by changing the relative amounts of sand and stone, but keeping the aggregate of 6 parts of sand and stone for the 1-2-4 concrete, and 9 parts of sand and stone for the 1-3-6 concrete.

The proportions of all materials shall be determined by measurement. The volume of a barrel of cement, 376 pounds, shall be assumed to be 3.6 cubic feet. The sand and stone shall not be packed more closely than by throwing in the usual way into a barrel or box at the time of measurement.

Cement. Portland cement shall be used, of the quality specified under "Cement".

Stone. The stone shall be clean hard crushed stone or pebbles, to be approved by the Engineer, composing the whole run of the crusher, in size from one-fourth inch to three-fourths inch, when used for bedding on metal decks, bridge seats, etc.; and from one-fourth inch to 1½ inches for other purposes, screened of dust and particles less than one-fourth inch.

Sand. Sand shall be clean and sharp and shall be composed of grains graded from fine to coarse, screened if required, to reject all particles of a greater diameter than one-fourth inch. It shall not contain more than a 5 per cent weight of clay, loam, dirt, or other impurities, and shall be equal in quality to the best New Jersey bank sand.

Care of Sand and Stone. Sand and stone when delivered on the work shall be dumped on platforms and not upon the ground.

Machine Mixing. All mixing shall preferably be done by machine, but hand mixing shall be allowed in special cases.

When mixed by machine, cubical box mixers, or those which allow of dry mixing of the materials before the water is added, shall be preferred. The proportions shall be accurately determined before being placed in the mixer and means shall be provided for accurately measuring the water.

(See water specifications, page 43.)

Measuring boxes or other approved apparatus shall be used, so that the proportions can be exactly determined. The ingredients shall be thoroughly mixed before the water is added, and the mixing shall be continued until every particle of stone is covered with mortar. No retempering shall be allowed under any conditions.

Hand Mixing. When mixed by hand, the cement and sand shall be first mixed dry and then made into a mortar. The stone shall be spread upon a suitable floor to a depth of about 6 inches and thoroughly wetted (see water specifications, page 43), and the mortar evenly spread over it, care being taken that the stone of each batch is mixed as to size. The whole mass shall then be turned over 4 times and raked to secure complete and uniform mixture. If the Contractor desires to use some other method, he shall submit it for approval. Should the mixture be permitted to set before placing or tamping, it shall be removed and

not used. Hand-mixed batches shall not be larger than 1 cubic yard in volume.

Depositing. All concrete shall be deposited in sections and in layers of such thickness — not exceeding 9 inches — as the Engineer shall direct. It shall be of such consistency that when dumped in place it will not require much tamping, but shall not be wet enough to cause the mortar to separate from the stone; it shall be spaded down and tamped sufficiently to level off and will then quake freely like jelly. Where concrete is marked on the face into courses, each requiring two or more layers, the layers shall follow each other in close succession before setting, so as to avoid visible joints on the face of a course.

Surface of Concrete Exposed to the Street. Surfaces of concrete exposed to the street shall be composed of 1 part cement, 2 parts coarse sand or gravel, and 2 parts granolithic grit, made into a stiff mortar. Granolithic grit shall be granite or trap rock crushed to pass a one-fourth-inch sieve and screened of dust. For vertical surfaces the mixture shall be deposited to a minimum thickness of 1 inch against the face forms by skilled workmen. This shall be done as the placing of the concrete proceeds, and thus form a part of the body of the work. Care shall be taken to prevent the occurrence of air spaces or voids in the surface. The face forms shall be removed as soon as the concrete has sufficiently hardened and any voids that may appear shall be filled up with the mixture.

The surface shall then be washed immediately with water until the grit is exposed; it shall then be rinsed clean, protected from the sun, and kept moist for 3 days. For horizontal surfaces, the granolithic mixture shall be deposited on the concrete to a minimum thickness of $1\frac{1}{2}$ inches, immediately after the concrete has been tamped and before it has set, and shall be troweled to an even surface; after it has set sufficiently hard, it shall be washed until the grit is exposed.

All concrete surfaces exposed to the street shall be marked off into courses in such detailed manner as may be directed by the Engineer.

Other Showing Surfaces. All other showing surfaces shall be prepared by keeping the stone well back from the face as the concrete is placed; this is done by bringing the mortar against the forms by "spading".

Horizontal exposed surfaces shall be finished with a layer of cement mortar, 1 part cement to 2 parts sand, 1 inch thick, and troweled to a smooth surface.

After the forms are removed the surfaces shall be pointed

where necessary and washed with neat cement applied with a brush.

Plastering the face after removing the forms shall not be permitted.

Protection of Exposed Surfaces. Provision shall be made to protect exposed surfaces from the action of the elements, until the concrete has set.

Forms. Suitable forms shall be constructed, the cost of which shall be included in the price per cubic yard for the concrete.

The dimensions shall be such that the finished concrete shall be of the form and dimensions shown on the plans or as ordered by the Engineer. All forms shall be set true to the lines designated and shall be built so as to remain firm and secure until the concrete has firmly set. They shall be satisfactory to the Engineer and shall remain in place as long as he deems it necessary. The interior surfaces of the forms which come in contact with the exposed surfaces of the concrete shall be of dressed lumber having close joints, and shall be so constructed as to leave all exposed surfaces of the concrete smooth, even, and presentable. Face forms shall have triangular beads secured to the planks to mark the face of the concrete into courses by imprint.

All top edges of copings, pedestal blocks, and bridge seats, the vertical angles of abutments, piers, and retaining walls, and the bottom edges of the rings of all arches shall be formed by placing fillets inside the forms as shown on the plans.

Cleaning Joints. In work above ground, the top surface of each course shall be scraped within 24 hours, to remove the "laitance" or scum, and insure the adhesion of the next layer.

Contraction Joints. Contraction joints shall be placed wherever directed by the Engineer. The sections of wall shall generally be about 50 feet in length, shall be made with tongue and grooved joints as directed, and corrugated asbestos boards shall be used on the faces of the joints. Payment shall be made for the corrugated asbestos boards at the price given in the proposal, but all other expenses attendant upon making the joint shall be included in the price per cubic yard of concrete.

Steel in Reinforcement. Rods for reinforcing concrete shall be of steel of some approved shape specially formed for that purpose and designed to secure an interlocking bond between the concrete and the steel. If the rods are twisted, the twists shall be made cold and shall be sufficient to give one complete turn in a length equal to 6 times the least diameter of the bar.

Imbedded Stone. If the Contractor shall so elect, approved hard stone not exceeding 6 to 8 feet may be imbedded in the foundation concrete; similar stone, but not larger than 2 cubic

feet each, may be imbedded in the neat work. The stones shall be thoroughly cleaned and placed so as to be entirely surrounded by concrete, and shall not be closer than 6 inches to any face of the work. In the neat work, the stones shall be imbedded so as to form dowels bonding each day's work.

Concrete Deposited under Water. In case it is found necessary to lay concrete under water, approved appliances shall be used to insure its being deposited with as little injury as possible.

Waterproofing

Percolation of Water to be Prevented. It is the very essence of these specifications to secure an underground structure which shall be entirely free from the percolation of ground water or outside water, to which end construction shall be carried out as follows:

Preparation of Foundations. After the soil has been excavated to the required depth and dressed off to a true grade as directed by the Engineer, there shall be laid a bed of concrete of the proportions herein described, and of such thickness as (in the judgment of the Engineer) the local conditions demand. On such bed, which shall be made as level and smooth as possible on the top surface, there shall be spread a layer of hot asphalt, and on such asphalt there shall be immediately laid sheets or rolls of felt, all of the quality hereinafter described; another layer of hot asphalt shall be spread over the felt; another layer of felt laid, and so on until not less than 2 such layers of felt nor more than 6 be laid, with asphalt between each layer, and asphalt beneath and on top of the whole. On top of the upper surface of asphalt, the remainder of the concrete as called for by the contract drawings shall be put in place. In dry open soil the felt in the floor concrete may be omitted, the base course of concrete being covered with one good layer of asphalt. In rock excavation, where the same is dry and above water level, both the felt and the asphalt in the floor may be omitted.

Side-Wall Construction. When the I-beam columns of the side walls are set and secured permanently in place, the concrete composing the side walls shall be rammed in place in such manner that the back or outer face is flush with the outer flanges of the columns. On such outer face hot asphalt shall be brushed and felt spread in alternate layers, in the same manner as described for the foundations, and the backing of concrete shall then be added, as shown by the plans. Instead of constructing the side walls with the waterproofing as described above, the Contractor may build in dry open soils, if permitted by the Engineer and if

no additional width of excavation is required for sewers or other purposes, a 4-inch brick wall supported at the back by the trench sheathing, laid in cement mortar or hot asphalt, and at a distance of at least 2 inches in the clear from the line of the exterior faces of the side-wall beams; and then he may attach to it the layers of waterproofing material as described above, and ram around the beams and against the waterproofing surface the concrete composing the side walls. Under similar conditions in dry rock excavation, the rock may be excavated so that no projecting point comes within 3 inches of the line of the exterior face of the side-wall beams; then the rough surface shall be made smooth with a plaster of concrete, and on such smooth surface the waterproofing material shall be spread; and then the concrete of the side walls may be rammed against the same in the manner described above.

Roof Construction. The roof of the structure shall be treated in a similar manner by finishing the jack arches to such height as may be directed by the Engineer, spreading the asphalt and felt in alternate layers, and then adding a cover of concrete, completing the roof as called for by the Contract Drawings.

Continuous Waterproof Envelope. By the arrangement above described there will be a continuous sheet of asphalt and felt imbedded within the concrete of the bottom, top, and both sides, and completely enveloping the structure.

Quality of Asphalt. The asphalt used shall be the best grade of Bermudez, Alcatraz, or lake asphalt of equal quality, and shall comply with the following requirements:

> The asphalt shall be a natural asphalt or a mixture of natural asphalts, containing in its refined state not less than 95 per cent of natural bitumen soluble in rectified carbon bisulphide or in chloroform. The remaining ingredients shall be such as not to exert an injurious effect on the work. Not less than two-thirds of the total bitumen shall be soluble in petroleum naphtha of 70° Baumé or in acetone. The asphalt shall not lose more than 4 per cent of its weight when maintained for 10 hours at a temperature of 300° Fahrenheit.

Coal Tar Prohibited. The use of coal tar, so-called artificial asphalts, or other products susceptible to injury from the action of water, will not be permitted on any portion of the work, or in any mixtures to be used.

Quality of Felt. The felt used in waterproofing such part of the structure as is below ground water level shall be composed

of asbestos or other equally nonperishable material dipped in asphalt and weighing not less than 10 pounds to the square of 100 feet. The felt used in other parts of the structure shall be the same as the above, or of the best quality of coal tar felt weighing not less than 15 pounds to the square of 100 feet; except that, if the latter be used, one layer more of it will be required than of the former. All felt shall be subject to the approval of the Engineer.

Surfaces to be Smooth. The surfaces to be waterproofed shall be smooth, without projecting stones, or made smooth where necessary by a coating of mortar made of one portion Natural cement to one portion sand, and should be dry before the asphalt is applied.

Artificial Drying. Means for artificially drying the surface of concrete may be taken by the Contractor by blowing warm air over it, or as otherwise permitted by the Engineer, but not until the concrete has had at least 48 hours in which to set.

No Cracks or Blowholes. Each layer of asphalt fluxed as directed by the Engineer must completely and entirely cover the surface on which it is spread, without cracks or blowholes.

Felt to be Carefully Laid. The felt must be rolled out into the asphalt while the latter is still hot, and pressed against it so as to insure its being completely stuck to the asphalt over its entire surface. Great care should be taken that all joints in the felt are well broken; that the ends of the rolls of the bottom layer be carried up on the inside of the layers on the sides; and that those of the roof be carried down on the outside of the layers on the sides, so as to secure a full lap of at least 3 feet. Especial care must be taken with this detail.

Skilled Men. None but competent men, especially skilled in work of this kind, shall be employed to lay asphalt and felt.

Top Surface of Asphalt not to be Broken. When the finishing layer of concrete is laid over or next to the waterproofing material, care must be taken not to break, tear, or injure in any way the outer surface of the asphalt.

Number of Layers of Felt. The number of layers of felt on the sides and under the floor shall in no case be less than 2 in ground that is quite dry; and where there is a water pressure against the masonry equal to 12 feet, there shall not be less than 6 layers. Where the water pressure is less than 12 feet, or where the ground is damp, such number of layers between 3 and 6 shall be used as the Engineer may direct. The number of layers of felt on the roof shall be not less than 3 of asphalted asbestos or 4 of tarred felt.

Bricks Dipped in Asphalt. At any point where the Contract

Drawings and the Engineer permit, the Contractor may lay, instead of the asphalt and felt above described, one or more courses of bricks dipped in hot asphalt of the above described quality, and laid while the coating of asphalt is still hot.

Asphaltic Concrete. In foundations, the Contractor may lay, if he prefer, instead of the ordinary concrete with the layer of waterproofing material, as above described, a bed of asphaltic concrete, composed of broken stone of the qualities previously described for concrete, heated in a suitable heater to such proper temperature as the Engineer may direct and, when so heated, have added thereto the melted asphalt of the quality as described above, in such proportion as to insure a covering of each particle of stone with asphalt; the whole mass shall then be thoroughly mixed and incorporated in a suitable mixer. Such asphaltic concrete shall be spread in place and thoroughly rolled and compressed, so that it will present a smooth even surface that will be impervious to water. No asphalt shall be heated to exceed a temperature of 325° Fahrenheit.

Waterproofing—When Omitted. In masonry-lined structures where there is no steel work and the ground is dry, the regular waterproofing may be omitted, but in that case in arched-cut and cover work the extrados of the arch shall be coated with hot asphalt of the quality described, or the best grade of refined Trinidad asphalt.

Leaky Masonry to be Rebuilt. Any masonry that is found to leak at any time prior to the completion of this work shall be cut out and the leak stopped, if so ordered by the Engineer.

LUMBER

Specifications. All lumber shall be sound, straight grained, and free from excessive sap, loose or rotten knots, wind shakes, or any other defect that would impair its strength or durability. It shall be sawed or hewed perfectly straight to exact dimensions, with full corners and square edges.

All long-leaf yellow pine shall be first-class Southern long-leaf yellow pine, sawed true and out of wind, full size, free from wind shakes, large or loose knots, or other defects impairing its strength or durability, and equal in quality to the grade of ..... * in "Interstate Rules of 1905, for Classification and Inspection of Yellow Pine Lumber".

All framing shall be done in a thoroughly workmanlike manner and both material and workmanship shall be subject to the

* Insert here the class of inspection desired, that is, Standard, Merchantable, or Prime. See "Specifications for Classification and Inspection of Lumber".

inspection and approval of, or rejection by, the Engineer. Only the timber actually called for in the plans shall be estimated and paid for. No allowance shall be made for waste.

INTERSTATE RULES OF 1905 FOR THE CLASSIFICATION AND INSPECTION OF YELLOW PINE LUMBER

EFFECTIVE ON AND AFTER FEBRUARY 1, 1905

General Rules

All the lumber must be sound commercial long-leaf yellow pine (pine combining large coarse knots with coarse grain is excluded under these rules), well manufactured, full to size, saw-butted, and free from the following defects: Unsound, loose, and hollow knots, wormholes and knotholes, and through shakes or round shakes that show on the surface. It shall be square-edged, unless otherwise specified.

A through shake is hereby defined to be a fissure through, or fissures connected from side to side, edge to edge, or side to edge.

In the measurement of dressed lumber, the width and thickness of the lumber before dressing must be taken; less than 1 inch thick shall be measured as 1 inch.

The measurement of wane shall always apply to the lumber in the rough.

Where the terms "one-half heart" and "two-thirds heart" are used, they shall be construed as referring to the area of the face on which measured.

In the dressing of lumber, when not otherwise specified, one-eighth inch shall be taken off by each planer cut.

Classification

Flooring. Flooring shall embrace 4, 5, and 6 quarter inches in thickness by 3 to 6 inches in width, excluding $1\frac{1}{2} \times 6$. For example: 1×3, 4, 5, and 6; $1\frac{1}{4} \times 3$, 4, 5, and 6; $1\frac{1}{2} \times 3$, 4, and 5.

Boards. Boards shall embrace all thicknesses under $1\frac{1}{2}$ inches by over 6 inches wide. For example: $\frac{3}{4}$, 1, $1\frac{1}{4}$, and $1\frac{3}{8}$ inches thick by over 6 inches wide.

Plank. Plank shall embrace all sizes from $1\frac{1}{2}$ to under 6 inches in thickness by 6 inches and over in width. For example: $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$, 5, $5\frac{1}{4}$, $5\frac{3}{4}$ by 6 inches and over in width.

Scantling. Scantling shall embrace all sizes exceeding $1\frac{1}{2}$ inches and under 6 inches in thickness, and from 2 to under 6 inches in width. For example: 2×2, 2×3, 2×4, 2×5, 3×3, 3×4, 3×5, 4×4, 4×5, and 5×5 inches.

Dimension. Dimension sizes shall embrace all sizes 6 inches and up in thickness by 6 inches and up in width. For example: 6×6, 6×7, 7×7, 7×8, 8×9, and up.

Stepping. Stepping shall embrace 1 to $2\frac{1}{2}$ inches in thickness by 7 inches and up in width. For example: 1, $1\frac{1}{4}$, $1\frac{1}{2}$, 2, and $2\frac{1}{2} \times 7$, and up in width.

Rough Edge or Flitch. Rough edge or flitch shall embrace all sizes 1 inch and up in thickness by 8 inches and up in width, sawed on 2 sides only. For example: 1, 1½, 2, 3, 4, and up thick by 8 inches and up wide, sawed on 2 sides only.

Inspection

Standard. All lumber shall be sound. Sap is no objection and wane may be allowed one-eighth of the width of the piece measured across the face of the wane, extending one-fourth of the length on one corner, or its equivalent on two or more corners, provided that not over 10 per cent of the pieces of any one size shall show such wane.

Merchantable. All sizes under 9 inches shall show some heart the entire length on one side; sizes 9 inches and over shall show some heart the entire length on two opposite sides. Wane may be allowed one-eighth of the width of the piece measured across the face of the wane, and extending one-fourth of the length of the piece on one corner or its equivalent on two or more corners, provided that not over 10 per cent of the pieces of any one size shall show such wane.

Prime. *Flooring.* Flooring shall show one heart face, free from through or round shakes or knots exceeding 1 inch in diameter, or more than 4 in a board on the face side.

Boards. Boards 7 inches and under in width shall show one heart face; over 7 inches in width, they shall show two-thirds heart on both sides, all free from round or through shakes, large or unsound knots.

Plank. Plank 7 inches and under in width shall show one heart face; over 7 inches in width, they shall show two-thirds heart on both sides, all free from round or through shakes, large or unsound knots.

Scantling. Scantling shall show three corners heart, free from through or round shakes or unsound knots.

Dimension Sizes. All square lumber shall show two-thirds heart on two sides, and not less than one-half heart on two other sides. Other sizes shall show two-thirds heart on face and show heart two-thirds of length on edges, excepting when the width exceeds the thickness by 3 inches or over; then it shall show heart on the edge for one-half the length.

Stepping. Stepping shall show 3 corners heart, free from shakes and all knots exceeding one-half inch in diameter and not more than 6 in a board.

Rough Edge or Flitch. Rough edge or flitch shall be sawed from good heart timber and shall be measured in the middle, on the narrow face, free from injurious shakes or unsound knots.

Wane shall be allowed on not over 5 per cent of the pieces in any one size, as on merchantable quality.

TERRA COTTA DRAIN PIPE FOR CULVERTS

The Contractor shall furnish and lay vitrified terra cotta pipe, according to place, size, and length, as shown on the plans and profiles, or as ordered by the Engineer.

Quality. The terra cotta pipe shall be of standard lengths and quality, double strength, made of the best material, thor-

oughly and perfectly burned, of homogeneous texture, without imperfections, and well glazed, so that its surfaces shall be smooth, hard, and even. The pipe shall be straight, not varying more than one-eighth inch from a straight line per foot of length; true to form; of full diameter throughout; of a thickness at least equal to that of double strength standard sewer pipe and of the same diameter; and it may have either socket or sleeve joints. The bells shall be of standard depth, and large enough to receive to their full depth all spigot ends without clipping and to leave a space of not less than ¼ of an inch all around for cement.

Laying. All pipe shall be laid true to line and grade given by the Engineer, and on good bottom. Unless timber and concrete foundations are indicated on the profile, an excavation of at least 6 inches in depth to receive the pipe shall be made to conform to the shape of the pipe. The pipe shall be laid in such length as to extend at least 1 foot beyond the foot of the slopes of the finished embankment unless otherwise ordered by the Engineer.

Joints. The space between the pipe and the socket shall be as uniform as possible, and shall be made water-tight by first using a small jute gasket, thoroughly saturated with neat cement, carefully coiled and calked in the bell of the pipe. The joints shall then be thoroughly filled with cement mortar, made of equal parts of cement and clean sharp sand, thoroughly mixed dry, water enough being afterwards added to give it the proper consistency, and the mortar shall be used as soon as made; after this the joint shall be carefully wiped inside and out, and pointed.

Interior of Pipe. The interior of the pipe shall be carefully cleaned of all dirt, cement, or superfluous materials of every description.

The Contractor shall make good all defects and remove any foreign matter which may have been left in or otherwise introduced into the pipe, before the final acceptance of the work.

Payment. Drain pipe shall be estimated and paid for by the linear foot in place, the price to include the pipe, the hauling, and placing as specified. Where shown on the profile, end walls for the drain pipe shall be constructed of masonry in accordance with the standard plans for end walls for pipe culverts, the concrete for same to be paid for at the price given in the proposal for No. 2 concrete.

CAST-IRON PIPE CULVERTS

The Contractor shall furnish and lay cast-iron water pipe according to place, size, and length as shown on the plans and profiles.

Quality. All cast-iron pipe shall be free from such defects and imperfections as shall, in the opinion of the Engineer, make it unacceptable for use as pipe culverts, and it shall be of standard thickness and length. Where it is necessary to use cut pipe, the cutting shall be done in such a manner as to leave a smooth end at right angles to the axis of the pipe.

Laying. All pipe shall be laid true to line and grade, and in such lengths that the ends of the pipe shall extend not less than 1 foot beyond the foot of the slopes of the finished embankments, unless otherwise ordered by the Engineer.

Blocking. Each length of pipe shall be laid upon blocking set at 3 different places along its length. It shall be of sound 3- by 10-inch planking and shall have a length equal at least to the diameter of the pipe. Wedges shall be placed on the blocking to hold the pipe in position. The blocks shall be bedded firmly and evenly across the line of pipe and, when any block has been sunk too deep, additional blocking shall be placed to bring the pipe to the required grade.

Joints. The space between the pipe and the socket or collar shall be as uniform as possible, and shall be made water-tight by being thoroughly filled with Portland cement mortar, made of equal parts of an approved cement and clean sharp sand.

Interior of Pipe. The interior of the pipe shall be carefully cleaned of all dirt, mortar, or superfluous materials of every description. The Contractor shall make good all defects and remove any foreign matter which may have been left in or otherwise introduced into the pipe, before the final acceptance of the work.

Payment. Cast-iron pipe shall be estimated and paid for by the linear foot in place, the price to include the pipe, the hauling, and the placing as specified. Where shown on the profile, end walls for the pipe shall be constructed of masonry in accordance with the standard plans for end walls for pipe culverts.

STRUCTURAL STEEL FOR BUILDINGS*

Steel. All steel may be made by either the Bessemer or the open-hearth process, except rivet steel and steel for plates or angles over $\frac{3}{4}$ inch in thickness which are to be punched, and these will be made by the open-hearth process. The finished products shall be straight and free from flaws and shall have clean smooth surfaces.

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* See specification for steel under Bridges, p. 65, as another example.

Schedule of Requirements. The requirements are as follows:

Chemical and Physical Properties	Structural	Rivet
Phosphorous maximum, Bessemer.....	0.10 per cent	.....
Phosphorous maximum, open-hearth.....	0.06 per cent	0.06 per cent
Sulphur	.....	0.045 per cent
		Desired
Tensile strength, lbs. per sq. in.....	55,000–65,000	48,000–58,000
Elastic limit, minimum per sq. in.....	½ tens. str.	½ tens. str.
Elongation—minimum per cent in 8 in....	$\frac{1{,}400{,}000}{\text{tens. str.}}$	$\frac{1{,}400{,}000}{\text{tens. str.}}$
Elongation in 2 in. minimum per cent.....	22	.....
Character of fracture.....	silky	silky

Bend Tests. The test specimens for plates, shapes, and bars shall bend cold through 180 degrees without cracking on the outside of the bent portion, as follows: For material ¾ inch to and including 1¼ inches in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1¼ inches in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen. For pins and rollers the test specimen shall bend cold through 180 degrees around a 1-inch pin, without cracking on the outside of the bent portion. For rivet steel the test specimen shall bend cold through 180 degrees, flat on itself, without cracking on the outside of the bent portion.

Annealing Tests. Material which is to be used without annealing or further treatment shall be tested in the condition in which it comes from the rolls. When material is to be annealed or otherwise treated before use, the specimen representing such material shall be similarly treated before testing.

Test Pieces. For each melt there shall be furnished by the Contractor, properly prepared, free of charge to the railway company, at least 1 tensile and 1 bending test.

Stock Material. No material shall be taken from stock without the consent of the Inspector. Such material shall be stamped with the original melt number and shall not have more than surface rust. In any case in which the rust has eaten into the material, the piece shall not be accepted.

Shop Work. All workmanship shall be first class in every particular and all parts shall be neatly finished.

STEEL BRIDGE SPECIFICATIONS

When specifications are contained in letter of invitation, or shown on accompanying plan, they shall supersede those herein which conflict therewith.

Should any question arise as to the interpretation of these specifications, the decision of the Chief Engineer of the..... Company shall determine the matter.

RAILROAD BRIDGES

General Clauses

Material. All bridges shall be constructed of rolled steel; but cast iron or cast steel may be used in the machinery of drawbridges, and wrought iron for laterals and unimportant members.

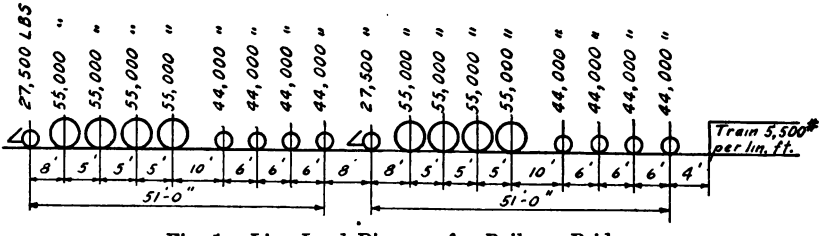


Fig. 1. Live Load Diagram for Railway Bridges.

Live Load. All structures shall be designed to carry, in addition to their own weight, the moving load shown in Fig. 1 or Fig. 2, moving simultaneously on each truck in the same direction.

For transverse trough or buckled plate floors, the live load shall be taken at 16,000 pounds per foot of track.

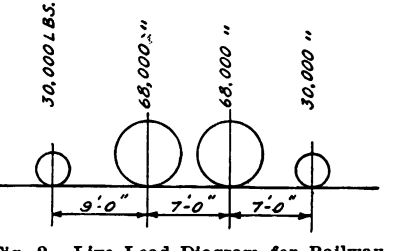


Fig. 2. Live Load Diagram for Railway Bridges.

Dead Load. The dead load shall consist of the weight of the metal in the structure and an assumed weight of 500 pounds per lineal foot of single track for the ordinary wooden floor, the rails, etc. For ballast floors the following weights shall be assumed:

Ballast	120 lbs. per cubic foot
Concrete	140 lbs. per cubic foot
Asphalt	90 lbs. per cubic foot
Lumber	54 lbs. per cubic foot

Wind Pressure. For girder bridges the wind pressure against each chord of the bridge shall be taken at 200 pounds per lineal foot. In addition to this, on the chord which carries the track, a

wind pressure of 400 pounds per lineal foot, with its point of application 7½ feet above the rail, shall be taken as a moving load.

For viaducts and trestle towers, on the unloaded structure, the wind pressure shall be taken at 50 pounds per square foot of the projected surface of two trusses and two sides of towers on the vertical plane through the axis of the structure; on the loaded structure, the pressure shall be taken at 30 pounds per square foot of this same surface and, in addition, the moving wind load specified for girder bridges.

For determining the requisite anchorage for the loaded structure, the train shall be assumed to weigh 600 pounds per foot.

Momentum of Train. The horizontal force developed by suddenly stopping a train shall be taken at one-fifth of the moving load.

Centrifugal Force. The centrifugal force shall be taken at 2 per cent of the moving load for each degree of curvature of the track—all the tracks being loaded. Centrifugal force shall be considered live load.

Spans. The spans assumed for calculation shall be as follows: For pin bridges, the distance between centers of end pins; for riveted bridges, the distance between centers of end bearings; for floor beams, the distance between centers of trusses; for stringers, the distance between centers of floor beams.

Depth. The depths assumed for calculation shall be as follows: For pin bridges, the distance between centers of chord pins; for riveted bridges, the distance between centers of gravity of flanges.

Stress Sheets and Plans. All parts shall be so designed that the stresses coming upon them can be accurately calculated.

Bidders shall submit with their bids a general plan and complete stress sheet, showing the loads used and the separate stress produced on each member by each of the foregoing loads and forces, and the sizes and arrangement of parts in sufficient detail for comparison with other plans.

Upon award of contract the Contractor shall furnish in duplicate to the Chief Engineer of the railway company blueprints of complete shop and erection plans showing all details, which shall be subject to the approval of the said Chief Engineer. Upon completion of the work all tracings shall be delivered to the Chief Engineer of the railway company. Tracings shall be of uniform size, and not larger than 30 inches by 42 inches.

Clearance. The gage of the track is 4 feet 8½ inches, and the distance between the tracks, center to center, is 13 feet.

The vertical clearance for through bridges shall be 22 feet above the top of the rails.

For single-track through bridges, on tangent with rails at the same level, the lateral clear width at the top of rails shall not be less than 10 feet 6 inches; from a height of 2 feet to a height of 17½ feet, it shall not be less than 14 feet; and at a height of 22 feet, it shall not be less than 6 feet (see Fig. 3).

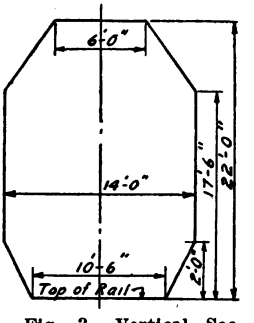


Fig. 3. Vertical Section of Clearance Dimensions on Bridges.

For double-track bridges and for curves and elevation of outside rail, the lateral clear widths shall be increased accordingly.

Wood Floor. The wood floor shall be shown as a standard bridge floor, plan dated.....

The wood floor shall be continued over all piers and back walls.

Unit Stresses and Sections

To provide for impact and vibrations the stresses produced by the live load shall be increased by the formula

$$I = S\,\frac{300}{L+300}$$

where I = amount to be added to the live load stress
S = calculated live load stress
L = length in feet of the loading which produces the maximum stress in the member

The unit stresses produced by the foregoing loads and forces, including impact, shall not exceed the following values:

tension, net section, 15,000 pounds per square inch

compression, $\dfrac{\text{15,000 pounds per square inch}}{1+\dfrac{l^2}{13{,}500r^2}}$

where l = length of member, center to center of connections, in inches
r = least radius of gyration in inches

No compression member shall have a length exceeding 100 times its least radius of gyration, except that wind bracing may have a length equal to 120 times its least radius of gyration.

Alternate Stress. Members subject to alternate tension and compression shall have a net sectional area equal to the sum of the areas required for the separate stresses.

Counters. When in any panel the shear from the live load, including impact, exceeds seven-tenths of the opposite shear from the dead load, the oblique equivalent of this excess shall be provided for. No counter rod, however, shall have a smaller section than 1 square inch.

Transverse Loading. In deck truss bridges, when the cross-ties rest on the chord, the sum of the direct thrust per square inch and three-fourths of the fiber stress per square inch produced by the maximum load on the chord panel considered as a supported beam—the pins being in the neutral axis of the section—shall not exceed the allowable compressive stress, the proper amount of impact being added to each kind of loading.

Should the pins be out of the neutral axis, the additional stress thus produced shall be provided for.

The sum of the direct stress per square inch on any member, and the fiber stress per square inch produced by its own weight, shall not exceed the allowed direct stress per square inch by more than 10 per cent.

Shop Rivets and Pins. The shearing stress shall not exceed 11,000 pounds per square inch of section; the pressure on the bearing surface (diameter $\times$ thickness of bearing) shall not exceed 22,000 pounds per square inch; the fiber stress due to bending, considering the centers of the bearings at the points of application of the stresses, shall not exceed 22,000 pounds per square inch.

For field-driven rivets a deduction of 20 per cent from the above values shall be made.

The size of the rivets before driving shall be considered their effective size for calculation.

Plate Girders. The bending moment shall be considered as resisted solely by the flanges, with no portion of the web assisting.

The shear in webs of plate girders shall not exceed 10,000 pounds per square inch. But no web shall be less than three-eighths of an inch thick. The entire end shear shall be considered as transferred into the flange angles in a distance equal to the depth of web. The pitch of rivets connecting the web to a top flange supporting the track shall not exceed 3 inches.

When the thickness of web plate is less than one-thirtieth of the unsupported distance between flange angles, stiffeners shall be riveted on both sides of the web, with fillers as thick as the chord

angles, and with close bearings against both flanges. For girders 30 feet long and less, the stiffeners shall be 3½ inches by 3 inches by ⅜-inch angles; for girders 90 feet long, they shall be 5 inches by 3½ inches by ⅜-inch angles; and for intermediate lengths, intermediate sized angles.

Generally, the stiffeners shall be placed at intervals equal to the depth of the web, with a maximum limit of 5 feet.

Generally, there shall be two pairs of stiffeners over each bed plate, their combined sectional area in square inches being equal to the total end shear in pounds, including impact, divided by 15,000.

Net Section. To obtain the net section of the bottom flange of plate girders or other members, all the rivet holes in any section, taken ⅛ inch larger in diameter than the rivet to be used, shall be deducted.

The top and bottom flanges shall have the same gross sectional area.

Cover plates shall be at least 12 inches longer than the net calculated length. When over 14 inches wide there shall be at least 4 lines of rivets, with pitch not exceeding 9 inches in any of the lines.

Sway Bracing. Efficient sway bracing and lateral bracing on top and bottom flanges shall be provided. Generally this bracing shall be of the same sized angles as the intermediate stiffeners. The unsupported length of flange shall not exceed 12 times its width, except as noted for track stringers.

Track Stringers and Floor Beams. Track stringers of double track through bridges and deck plate girders shall generally be spaced 6 feet, center to center, under each track. For single track through truss bridges the stringers shall be 8 feet, center to center.

Track stringers shall be riveted into the floor beams and shall bear upon the bottom flange of floor beams, or upon brackets which bear upon the bottom flange of floor beams; but the value of this bearing shall not be considered in computing the number of rivets required in the stringer connections.

Floor beams with riveted end connections shall bear on the bottom flange of the main girder, or on a bracket, in all cases where such bearing can be provided; but the value of this bearing shall not be considered in computing the number of rivets required in the connection. In case such bearing cannot be provided, then the number of rivets in the connection shall be 25 per cent more than the computed number.

In the connection angles between the stringers and floor beams, and other similar angles or plates, the shear shall not

exceed 7000 pounds per square inch; but no connection angle shall be less than five-eighths of an inch thick.

When the length of stringer exceeds 20 times the width of flange, lateral bracing shall be provided between the flanges.

The webs of floor beams shall be of the same thickness at center of beams as at the ends.

Minimum Thickness. The minimum thickness of metal used shall be three-eighths of an inch except for lattice bars or for fillers where a lesser thickness is required.

Combined Stresses. In case the sum of the stresses per square inch in the chords and end posts of truss bridges, or the posts of trestle towers—due to the live load including impact, the dead load, and the wind—shall exceed 19,000 pounds per square inch properly reduced for compression, the section shall be increased until this limit is not exceeded.

In the end posts of through bridges the sum of these stresses added to the maximum fiber bending stress per square inch, produced by the portal bracing, shall not exceed 20,000 pounds.

Should the stresses be reversed in any case, proper provision shall be made for such stresses.

Portals and Diagonal Bracing. All through spans with top lateral bracing shall have riveted portal bracing composed of angles, latticed as deep as the headroom will allow, rigidly connected to the end posts.

When the height of the truss exceeds 25 feet, an approved system of overhead diagonal bracing shall be provided at each panel point.

Deck bridges shall have diagonal bracing at each panel point proportioned to resist the unequal loading of the trusses; the position of the track, and the action of the wind and the centrifugal force being considered.

Pony trusses and through plate girders shall be stayed by knee braces or gussets at each floor beam or transverse strut, and at the ends.

No lateral or diagonal rod shall have a smaller area than 1 square inch.

Expansion Rollers, etc. All bridges exceeding 75 feet in length shall be anchored to the masonry at one end, and shall have at the other end nests of turned friction rollers, not less than 4 inches in diameter, running between planed surfaces. The pressure per lineal inch on these rollers shall not exceed $1200\sqrt{d}$ pounds—d being the diameter of the roller in inches.

For bridges less than 75 feet in length one end shall be free to move on planed surfaces.

Variations in temperature of 150° F. shall be provided for. Provision shall be made at movable ends against side motion.

Bed Plates. The pressure of bed plates on the masonry shall not exceed 400 pounds per square inch. When two spans rest on the same masonry, a continuous rolled plate $\frac{3}{4}$ inch thick shall extend under the adjacent bearings.

All bed plates shall have efficient stone bolts fastened with sulphur or cement.

Joints and Splices. All joints in riveted work, whether in tension or compression, shall be fully spliced.

Chord sections shall be connected at abutting ends by splices sufficient to hold them true to position, and to transmit the shearing stress at the joint.

Web plates of girders shall be spliced at all joints by a plate on each side, capable of transmitting the entire shear through the splice rivets.

Rivets. The pitch of rivets in the direction of the stress shall not exceed 6 inches, nor sixteen times the thickness of the thinnest outside plate connected, nor be less than three times the diameter of the rivet. At right angles to the stress, the pitch shall not exceed thirty times the thickness of the thinnest outside plate.

At the ends of compression members the pitch shall not exceed four diameters of the rivet for a length equal to twice the width of the member.

The distance from the edge of any piece to the center of rivet hole generally shall be not less than $1\frac{1}{2}$ inches, nor more than 5 inches, nor more than 8 times the thickness of the plate.

Tie Plates. All segments of compression members connected by latticing only shall have tie plates at each end, the rivets and net section of which shall be sufficient to transfer one-half the total maximum stress borne by the segment, and the thickness of which shall be not less than one-fiftieth of the distance between the rivets connecting them to the compression member. In no case, however, shall the length of the tie plate be less than its width across the segments.

Latticing. The open sides of compression members shall be stayed by tie plates at the ends, and by intermediate diagonal latticing.

Generally, the thickness of single lattice bars shall not be less than one-fiftieth, and the thickness of double bars, connected by a rivet at their intersection, shall not be less than one-sixtieth of the distance between rivets connecting them to a member. The inclination of lattice bars with long axis of members shall approximate 60 degrees for single lattice and 45 degrees for double lattice,

and the distance between points of connection of the latticing along a segment shall not be more than 8 times the least width of the segment. The width of lattice shall be as follows:

Length of Lattice	Width
Under 10 inches	2 inches
Under 15 inches	2¼ inches
Under 20 inches	2½ inches

For the chords and end posts of truss bridges the lattice shall be generally 3 inches by seven-sixteenth inch.

Pins. The members bearing against any pin shall be so packed as to produce the least bending moment upon the pin, and all vacant spaces must be filled with filling rings.

All pins requiring driving shall be supplied with pilot nuts for use in erection.

Preference. Preference will be given to details which will be most accessible for inspection and painting. No closed sections will be allowed.

Stiff lateral bracing shall be preferred for use between the chords which carry the floor.

Preferably all sections shall be made symmetrical, and the pins placed in the neutral axis. Bending moments at connections shall be avoided as much as possible.

Tension at the foot of trestle posts shall be avoided where practicable.

Camber. Truss bridges with parallel chords shall be given a camber by making the panel lengths of the top chord longer than those of the bottom chord in the proportion of one-eighth of an inch to every 10 feet.

In the wood floor one-half the camber shall be taken out unless otherwise directed.

Bolts. When members are connected by bolts which transmit shearing stress, the holes shall be reamed parallel and the bolts turned to a driving fit.

Screw Ends. In tension members with screw ends, the area at the base of the threads must be at least 15 per cent greater than that required in the body of the member.

Upsetting, etc. The heads of eyebars and the enlarged parts of rods with screw ends shall be made by upsetting, rolling, or forging into shape. Welds in steel bars will not be allowed. In iron bars they will only be allowed to form the loops of laterals, counters, or sway rods.

Quality of Material

Steel. All steel shall be made by the open-hearth process, and shall be uniform in quality. The finished products shall be straight, free from flaws, and have clean smooth surfaces.

Identification of Material. Copies of all bills of material, shipping lists, and complete chemical analyses showing the amount of phosphorus, carbon, sulphur, and manganese shall be furnished by the Contractor free of charge. All material shall be plainly stamped with the number of the melt. Rivet and lattice steel and other small parts may be bundled, with the above marks on an attached metal tag.

Schedule of Requirements. The requirements are as follows:

Chemical and Physical Properties	Structural Steel	Rivet Steel	Steel Castings
Phosphorous maximum... {Acid	.08	.04	.08
{Basic	.04	.04	.05
Ultimate Tensile Strength per square inch	Desired	Desired	Not less than
	60,000	50,000	65,000
Elastic Limit not less than	½ Ten. Str.	½ Ten. Str.	.45 Ten. Str.
Elongation, minimum per cent in 8 inches	1,500,000	1,500,000	
	Ult. Ten. Str.	Ult. Ten. Str.	
Elongation, minimum per cent in 2 inches	.....	.....	18
Character of fracture	Silky	Silky	{Silky or fine granular

Cold Bends. Samples of structural and rivet steel up to seven-eighths inch in thickness shall bend to close contact without fracture on the convex side. For greater thickness, sample shall bend 180 degrees to a curve of diameter equal to thickness of specimen, without fracture.

Samples of cast steel 1 inch by one-half inch shall bend 90 degrees around a diameter of 1 inch without fracture on outside.

Tensile Tests. Tensile tests of steel showing an ultimate tensile strength within 5000 pounds of that desired will be considered satisfactory, except that if the ultimate strength varies more than 4000 pounds from that desired, a retest shall be made on the same gage which, to be acceptable, shall be within 5000 pounds of the desired ultimate.

Chemical Analyses. Check chemical analyses shall be made from the finished material, if called for by the Chief Engineer, in which case an excess of 25 per cent above the required limits will be allowed.

Material which is to be used without annealing or further

treatment shall be tested in the condition in which it comes from the rolls. When material is to be annealed or otherwise treated before use, the specimen representing such material shall be similarly treated before testing.

Drifting. Material punched as in ordinary practice, shall stand drifting until the diameter of the hole is increased 50 per cent without cracking in the periphery of the hole or in the external sheared or rolled edge.

Test Pieces. For each melt there shall be furnished by the Contractor, properly prepared, free of charge to the railway company, at least one tensile and one bending test. Drifting tests shall be furnished occasionally during the progress of the work.

In general, tests shall be selected to cover extreme gages. Material will not be accepted on tests cut from pieces of radically different size or section from that used in the work.

Every test specimen shall be at least one-half square inch in area, and shall be planed, sawed, or turned with sides parallel.

Plates. Plates up to 36 inches wide shall be rolled in a universal mill. Long plates shall not be more than one-half inch out of line in a length of 20 feet, nor three-fourths inch in a length of 40 feet.

Variation in Gage. All shapes shall be rolled to gage. All plates, both sheared and universal, shall be of specified gage on edges. Shapes or plates 3 per cent less than thickness specified shall be rejected, except that in the case of plates 80 inches wide or over a variation of 5 per cent will be allowed.

Stock Material. No material shall be taken from stock without the consent of the Inspector. Such material must be stamped with the original melt number, and must not have more than a surface rust. If any piece of material sent either from the mill or stockyard is rusted when needed in the shop, this rust must be scraped off before the piece is punched. In any case in which the rust has eaten into the material, the piece will not be accepted.

Full-Sized Eyebar Tests. Full-sized tests shall be ordered by the Engineer, and in general will be not more than 4 per cent of the total number of bars in the structure.

The bars shall show an ultimate strength of not less than 55,000 pounds per square inch; an elastic limit of not less than one-half the ultimate strength; and an elongation taken between the necks of the bars of not less than 12 per cent, for bars 20 feet and less between necks. For bars exceeding 20 feet, the elongation shall be not less than 10 per cent.

Fracture. In all full-sized tests, 75 per cent of the fractured area shall be silky, the remainder fine granular.

Retests. If one bar of a lot breaks in the head but fulfills the

above requirements, the lot shall not be rejected on that account. If several bars break in the head but fulfill the above requirements, an additional bar for a retest shall be furnished by the Contractor free of cost to the railway company. If more than one-third of the total number of bars tested break in the head the entire lot of bars shall be rejected.

Full-sized members tested to destruction shall be paid for by the Company at cost, less their scrap value, if they fulfill the requirements specified. If they do not, they shall be paid for by the Contractor.

Cast Steel. All steel castings shall be practically free from blowholes and shall be thoroughly annealed.

Wrought Iron. All wrought iron shall be tough, ductile, fibrous, and of uniform quality. Finished bars shall be perfectly welded and have a smooth finish throughout, free from cinder spots, blisters, cracks, buckles, or imperfect edges.

Test specimens shall show an ultimate strength of 50,000 pounds per square inch, an elastic limit of at least 26,000 pounds per square inch, an elongation of at least 20 per cent in a length of 8 inches, and shall stand bending cold 180 degrees to a curve of diameter equal to twice the thickness of specimen, without sign of fracture.

Cast Iron. Unless otherwise specified, all castings shall be tough gray iron, free from cracks, cinders, blowholes, or other imperfections, and of workmanlike finish.

Sample pieces 1 inch square, cast from the same heat of metal in sand molds, shall be capable of sustaining, on a clear span of 4 feet 6 inches, a central load of 500 pounds when tested in the rough bar.

Timber. Unless otherwise specified, the timber shall be first-class Southern long-leaf yellow pine, sawed true and out of wind; full size; free from wind shakes, large or loose knots, or other defects impairing its strength or durability; and equal in quality to grade of "Prime", in Interstate Rules of 1905 for classification of yellow pine lumber. (See page 52.)

Shop Work

Workmanship. All workmanship shall be first class in every particular and all parts neatly finished.

Straightening. All material shall be thoroughly straightened in the shop, before being laid off, by methods that will not injure it and, if bent by punching, shall be again straightened before bolting up.

Punching. In all punched work the diameter of the die shall

be not more than one-sixteenth inch greater than the diameter of the punch.

All holes shall be perpendicular to the surface of the punched piece, and be clean-cut, without torn or ragged edges.

Rivet holes shall be so accurately spaced and punched that, when the parts of a member are assembled, a rivet one-sixteenth inch less in diameter than the hole can be entered hot into the holes. Occasional variations shall be corrected by reaming.

Reaming. Steel up to and including a thickness of five-eighths inch may be punched without subsequent reaming. Steel of greater thickness than five-eighths inch shall be drilled or punched one-eighth less than the diameter of the rivet and reamed to a diameter of one-sixteenth inch greater than the diameter of the rivet. The reaming of the rivet holes may be done after the various pieces have been punched and assembled, but every hole after reaming shall show that the reamer has everywhere touched the metal. Sheared edges and ends in all metal over five-eighths inch in thickness shall be planed at least one-eighth inch.

Riveting. The rivet when driven shall completely fill the holes, have full round heads concentric with the rivet, of a height not less than three-fifths the diameter of the rivet (unless otherwise shown on the plans), and in full contact with the surface, or be countersunk when so required.

Rivets shall be machine driven wherever possible, by machines capable of retaining the applied pressure after the upsetting is completed. Pneumatic hammers shall be used in preference to hand driving.

Tightening rivets by calking or re-cupping will not be allowed.

Finished Members. Built members, when finished, shall be true and free from twist, kinks, buckles, or open joints between the component pieces.

Eyebars. Before boring, each eyebar shall be properly annealed and carefully straightened. They shall be free from flaws; of full thickness in the neck; the thickness of the heads shall not be more than one-sixteenth inch greater than the thickness of the bar; and the hole shall be in the center of the head and on the center line of the bar. No forge work shall be done on bars after they are bored.

No variation from the calculated length between pinholes of more than one-sixty-fourth of an inch for each 25 feet will be allowed. Whenever bars are to be packed more than one-eighth of an inch to the foot of their length out of parallel with the axis of the structure, they shall be bent with a gentle curve until the head stands at right angles to the pin in their intended position before being bored. All bars belonging to the same panel shall be

placed in a pile and shall allow the pins to pass through both ends at the same time without forcing.

Pins and Pinholes. Pins shall be turned straight and smooth, and shall fit the pinholes within one-fiftieth of an inch for pins 4 inches or less in diameter, and within one-thirty-second of an inch for larger pins.

Pinholes shall be bored clean and smooth, to a true parallel with one another, within one-thirty-second of an inch of the specified distance apart, center to center, and at right angles to the axis of the member, unless otherwise shown on drawings.

Facings. Eyes of laterals, stirrups, sway rods, and counters shall be bored.

All abutting surfaces in compression members shall be truly faced to even bearings.

The ends of track stringers and floor beams shall be faced true and square.

Reaming. All holes for field rivets except those for lateral and sway bracing connections shall be drilled to an iron template or reamed while the parts are temporarily put together.

Shop Erection. Adjoining chord sections shall be fitted together in the shop and all parts match marked; and when so fitted their abutting ends must be in full contact and the two sections in perfect alignment.

Other parts of the structure shall be erected in the shop when so required by the Inspector.

Rivets. In riveted steel work all rivets shall be of steel.

General Annealing. All members or parts of members which have been partly heated or worked at blue temperatures shall be properly annealed.

Painting

Painting in Shop. Before leaving the shop all work shall be thoroughly cleaned from all loose scale and rust, and given one good coat of pure linseed oil, well worked into joints and open spaces.

In rivet work, the surface to come in contact shall be painted before riveting together.

Parts which are not accessible for painting after erection shall have, in addition to the coat of oil, two coats of paint before erection.

Painting After Erection. After erection, the entire structure, except the wood floor, shall be thoroughly and evenly painted with two coats of paint, by practical painters. The two coats shall be different in color.

When work is delivered f. o. b., ready to be dropped into place, it shall be given only the above coat of oil before loading.

Materials. The materials for the field paint will be furnished by the railway company to the Contractors at the freight station nearest the bridge at the following prices: For the paste, — (—) cents per pound; for the Japan, — dollar and — cents ($—) per gallon, and for the linseed oil, — (—) cents per gallon.

No material shall be painted or oiled when it is wet.

Pins, pinholes, screw threads, and other machine-finished bearing surfaces shall be coated with white lead and tallow before leaving the shop.

Inspection

Inspection Facilities Furnished by Contractor. Due notice that material is ready for inspection shall always be given.

All facilities for inspection of material and workmanship shall be furnished by the Contractor, and free access to any works in which any portion of the material is made shall be allowed.

The Contractor shall furnish, free of cost, the use of an efficient testing machine at all mills where any of the material may be manufactured.

Such specimens (prepared) as may be required for testing shall be promptly furnished, without charge, by the Contractor.

No shop work shall be done on any material until it has been inspected and accepted.

Copies of all shipping invoices from mills or shops shall be promptly furnished the Inspector.

No material shall be loaded for shipment until it has been accepted by the Inspector.

The acceptance by an Inspector of any material or workmanship shall not prevent the rejection of the same, if it is afterwards discovered to be defective.

Erection

Previous to and during erection all material shall be kept clean, and shall be carefully handled, so as not to injure any of the parts.

Replacing Bridge. In case of replacing a bridge, the Contractor shall carefully take down the old structure and neatly pile the material at some point near the bridge convenient for loading on cars. If the old bridge is to be erected again, special care shall be taken not to injure any of the parts, and the different pieces shall be plainly marked at connections by the Contractor, in order to facilitate re-erection. All material in the old structure shall remain the property of the railway company.

Staging and False Work. The Contractor shall furnish all staging and false work, and provide for carrying traffic during erection, and so prosecute his work as to interfere as little as possible with the traffic over the bridge, or under the bridge, if there should be any such.

Any work affecting the safety of the track shall be subject to the direction of the Division Superintendent of the .....Railway Company.

Main Work. The Contractor shall furnish, erect, and adjust the entire structure, including the wooden floor, complete, ready for the rails. He shall also remove all false work after the erection is completed, and repair any damage produced by his operations.

Watchmen. The Contractor shall provide watchmen and other safeguards during erection, and shall be responsible for any accident or damage to person or property arising from his negligence or default; and he shall comply with all laws, ordinances, and regulations of properly constituted authorities, should there be any such affecting the work.

The Contractor shall be responsible for the work until it is finally completed and accepted by the Chief Engineer of the .....Railway Company.

HIGHWAY BRIDGES

Loads. Highway bridges shall be proportioned to carry the following moving loads in addition to their own weight:

On the floor system for all spans .....100 pounds per square foot of floors
Or a concentrated load of 8 tons on two pairs of wheels, 8 feet centers
On the trusses, for spans of 60 feet or less.....100 pounds per square foot of floors
On the trusses, for spans 60 feet to 125 feet..... 80 pounds per square foot of floors
On the trusses, for spans over 125 feet..... 60 pounds per square foot of floors

Impact. Allowance for impact shall be one-half as great as for railroad bridges.

Unit Stresses. The allowed unit stresses shall be the same as for railroad bridges.

On yellow pine floor joists the allowed fiber stress shall be 1600 pounds per square inch.

Requirements. The requirements as to quantity of material, workmanship, painting, erection, etc., shall be the same as hereinbefore specified for railroad bridges.

PRICE

Bidders shall name in their bids a lump sum for furnishing and transporting all labor and materials of every kind necessary to complete the superstructure in place, ready for the rails in railroad bridges, or ready for the traffic in highway bridges, in strict accordance with these specifications. Bidders shall state in their tenders, that for the price named they will complete the superstructure at or before a specified time; and if it is not completed at the specified time, the price shall be _____ dollars less than the sum named, for every day after the specified time that the structure remains unfinished; provided that no reduction in price shall be made for delay caused by the masonry not being ready to receive the superstructure.

TUNNELS

Approach Cuts. The approach cut shall be excavated to such widths and slopes as the said Chief Engineer may direct, and all the materials from the cuts and the ends of the tunnels shall be placed in embankments on the line of the railroad, on roads adjacent, or wasted, as the said Chief Engineer may direct, and they shall be classified and paid for according to the excavation classification of these specifications.

Dimensions. Tunnels shall be of such width and height as the said Chief Engineer may direct, and shall be excavated in conformity with the cross section to be furnished by him. If the tunnel requires support, and timber is adopted, the area of its cross section shall be enlarged and measured 3 inches outside the lagging; or, if masonry is adopted, 6 inches outside the exterior lines of the side walls and arching.

Classification and Price of Excavations. Materials from tunnel excavation shall be paid for by the cubic yard, or by the lineal foot, completed, in case such bid is accepted. The price paid shall cover all materials contained between the two portals, and strictly in all cases within the lines of the normal or enlarged cross section furnished from time to time by the said Chief Engineer, and shall include the cost of all temporary supports, such as props, scaffolding, strutting, etc., that may be necessary to secure a safe prosecution of the work in advance of the introduction of permanent supports of timbering or masonry, which tempo-

rary supports shall in all cases be removed by the said Contractor at his own expense after or concurrently with the completion of the permanent supports.

Bottoms. The bottom shall be picked to a uniform surface, and no rocky protuberances shall be allowed inside the general line of the sections.

Drainage Ditches. The drainage ditch through the center of the tunnel shown on the drawing of the normal cross section shall be carefully excavated to its full dimensions, and in it shall be laid broken stone in such manner and of such size and form as the said Chief Engineer may direct.

Shafts. The said Chief Engineer shall determine the number and location of shafts, the dimensions of which shall be such as he may direct. The excavation price paid for them shall be by the cubic yard, and shall cover all materials contained between the surface of the ground and soffit of the tunnel, and within the area of the cross section furnished by the said Chief Engineer. In case the shaft is sunk alongside the tunnel, the price paid shall cover the cost of such curbing or other supports as the sides of the shaft may require; also whatever materials or labor may be required for ventilation and keeping the tunnel and shafts free from water; and shall also cover all hoisting and pumping machinery.

Sumps. The excavation of all necessary wells or sumps shall be paid for at the same price per cubic yard as shaft excavation.

Niches. Niches or openings shall be left in the walls when and at such points as the Chief Engineer may direct.

Falls. Drilling and blasting shall be conducted with all possible care, so as not to shatter the roof and the sides outside the section lines. Any falls that, in the judgment of the said Chief Engineer, are attributable to the carelessness or want of proper skill or attention on the part of said Contractor, shall be removed and disposed of at his own expense; but if by unavoidable accident or natural causes not thus attributable, any outside rock shall become loose or shattered, it shall be removed by the said Contractor, and a just and equitable allowance shall be made by the said Chief Engineer to compensate and remunerate him for such removal, provided a claim for such removal be made by the said Contractor during the month in which a fall so occasioned shall occur.

Permanent Supports. Should it be determined by the said Chief Engineer during the progress of the work that any tunnel or any portion of a tunnel requires permanent supports, or that the shafts require lining, timber or masonry of brick or stone

may be used for such supports and lining, as the said Chief Engineer may direct.

Timber. If timber is used, the said Chief Engineer shall determine its description and quality and shall prescribe the general plan of the support, and it shall be paid for by the 1000 feet, board measure, framed, and placed in the work.

Iron Work. All wrought- and cast-iron work ordered by the said Chief Engineer and used in the work shall be paid for by the pound, in place.

Masonry. When lining or arching of brick or stone masonry shall be ordered, it shall be laid in the most skillful and workmanlike manner, and strictly in accordance with the plans and directions prescribed by the said Chief Engineer from time to time, to suit the necessities of each case as it occurs.

Should it be determined to erect masonry façades at the portals of the tunnels, or to finish out above the surface any or all of the shafts with ventilators, such work shall be executed by the said Contractor in accordance with such plans and directions as may be prescribed by the said Chief Engineer for the same.

All masonry used in and about tunnels shall be classified and paid for under the masonry classification of these specifications.

Timbering Must Follow Excavation. The commencement, extent, and termination of all permanent timbering and masonry shall be determined by the said Chief Engineer and, when so determined, such timbering or masonry must progress right along with the excavation; and, if necessary, the excavation shall be secured and protected by temporary supports before the introduction of permanent ones.

Packing. The vacancies behind the permanent timber, lagging, or masonry walls, and above the arching, shall be filled with concrete and dry packing, as the said Chief Engineer may from time to time direct, which packing shall be classified and paid for under the masonry classification of these specifications. Dry packing shall consist of hard durable stone, approved by the said Chief Engineer, broken to the required size to pack well, and shall be well rammed in.

Work Required Before Acceptance. Before tunnels are accepted their whole length shall be entirely cleared of débris, rubbish, and surplus materials of every kind, and the bottom dressed off true to the grade line, and the drains cleaned out, as directed by the Chief Engineer.

Night Work if Required. All work incident to the construction of tunnels shall be carried on by 2 shifts of 10 hours each, or 3 shifts of 8 hours each, as the said Chief Engineer shall direct.

BORINGS FOR A SUBAQUEOUS TUNNEL

General Specifications. The work to be done under this contract is to determine carefully by borings the character of materials that will be encountered during the construction of two tunnels under the.....River and under streets of both the Cities of.....and...... The borings shall be made at regular intervals 100 feet apart on the lines as shown on the plan attached hereto.

The borings on land will approximate 3000 lineal feet, while those taken in the river, measured from the bottom of same, will aggregate about 2400 lineal feet. The dotted line on the profiles indicates the depth to which it is proposed to take the borings. No payment will be made for borings made to a greater depth than that thus indicated, without a written order from the Engineer.

Quantities Approximate. It will of course be understood that the approximate quantities given above are not to be used in making payment, but that payments will be made upon quantities determined by the Engineer.

Boreholes Cased. All holes bored shall be cased with 4-inch pipe, and the character of all material passed through from the surface of the ground or bottom of the river must be carefully determined, and the depth of all changes in the stratification from the surface of the ground or low water mark shall be noted.

Preservation of Samples. Samples of the various materials encountered shall be preserved and placed in glass jars, bottles, or tubes, as the Engineer may direct, the same to be carefully labeled, giving the number of boring and the depths between which the material is found. Upon the completion of the work all samples shall be delivered at the office of the Company.

Borings to Rock. If directed by the Engineer, the borings shall be carried to rock formation and into same, to hard rock. Should rock be encountered above the dotted line shown in the drawing (profile drawing should always be submitted with regular specifications), borings shall be carried down only to hard rock.

Repaving. Upon the completion of a boring, the casing pipe shall be withdrawn and, wherever street paving shall have been disturbed by the work, it shall be restored to its original condition upon the completion of each boring, in a manner satisfactory to the proper city officials, without cost to the Company.

Ground Water. A record shall be kept at each borehole on land, of the depth of ground water below the surface of the ground.

Price to Include. Payment will be made for all borings at the price per vertical foot of hole bored, no allowance being made for the depth of the water where the boring is made; said price to include the removal of all material excavated within the casing and all pipe, pumping (with the proper appliances and appurtenances), transportation, glass jars or tubes for samples, materials, floats, scows, tools, and labor necessary for the completion of the above described work in the best, most rapid, and most approved manner.

Violation of Laws. The Contractor shall assume all blame or loss by reason of neglect or violation of the United States Government or municipal laws, regulations, or ordinances. The Contractor shall place sufficient light on or near the work, keep the light burning from twilight to sunrise, and observe such rules relative to signals and safeguards as the laws, regulations, or ordinances require.

Watchmen and River Signals. The Contractor shall provide at his own expense the necessary watchmen, signals, and lights, and must observe the local laws of the district in protecting the public against all injury and damage. He shall conform to all the rules and laws relating to navigation in the waters crossed by structures covered by this contract, and shall notify the proper authorities of the location of or change in position of proposed structures and plant in said waters, and shall establish and maintain the necessary lights, fog signals, etc., upon structures in course of construction, and upon his plant. In case of any damage resulting from neglect to keep and maintain suitable lights and signals, or from mistake in signals, it must be promptly repaired at the expense of the Contractor.

Inspection. The Contractor shall execute the work under this contract in the presence of an Inspector at all times; work done in absence of same shall be subject to rejection.

PILE TRESTLE FOR AN ELECTRIC RAILROAD ACROSS AN OCEAN INLET

General Specifications. The trestle shall consist of a single track structure extending out from either shore and across the various channels, as shown on the plans.

The piles which are not exposed to salt water shall be of white oak, while the other piling in the trestle, fenders, guard, and rest piers, exposed to salt water, shall be treated with creosote oil as herein specified, the timber in same being of quality as specified under "Piling".

The piles, both vertical and battered, shall be jetted and driven to the depth shown on the plan. They shall be driven in the bents of the trestle, in the guard piers, and in the foundation for piers, for the watchmen's houses, and for the refuge bays.

The quality of lumber and the workmanship on all structures shall be as specified under "Timber and Framing". Creosoted timber and galvanized iron shall be used where shown.

The trolley poles on the trestle shall be of Southern long-leaf yellow pine, 35 feet long, sawed to octagonal shape, measuring not less than 8 inches between parallel faces at the top and not less than 14 inches between faces at the base. They shall be attached to the trestle as shown, securely, and in a workmanlike manner, and shall be erected accurately to line and grade.

The price bid for the work shall include the furnishing and erection of all lumber, piles, and hardware in place, complete with all appurtenances.

TIMBER AND FRAMING

Quality. All timber must be sound, straight grained, and free from excessive sap, loose or rotten knots, wind shakes, wormholes, or any other defects which would impair its strength or durability. It must be sawed or hewn perfectly straight to exact dimensions, with full corners and square edges. All timber shall be long-leaf yellow pine or white oak. All yellow pine shall be long-leaf Southern yellow pine, and must satisfy the requirements under "Merchantable Inspection" in the Interstate Rules of 1905 for the classification and inspection of yellow pine lumber.

Workmanship. Material and workmanship shall both be subject to inspection, and approval or rejection, by the Engineer. The fenders, rest, and guard piers, pile trestle, and refuge bays shall be built according to the plans and directions given by the Engineer, and of materials as specified under timber, framing, and iron work.

Framing. All framing must be done in a thorough and workmanlike manner. No open joints, blocking, or shims will be allowed; the bearing of caps and stringers must all be sized, and perfect bearings must be secured throughout. The side with most sap shall be placed downward. All timber shall be squared off with the saw. The holes for the bolts shall be bored with an auger of the exact diameter of the bolts. The nuts on all bolts shall be screwed up tight so that the washers shall draw hard upon the timber and bring all parts of the structure close together.

Surfacing Ties. All bridge ties will be furnished and placed in the bridges by the Contractor, surfaced and brought to a true plane under the rails, so that they will have a full bearing on the four stringers, and so that the rails will have an even bearing on every tie.

Surfacing Stringers. All track stringers shall have their upper surfaces brought to a true plane, so that the ties may have an even bearing on all the stringers.

Elevating Outer Rail. Where any framed or pile trestle bridge is built on a curve, the blocking, or other means for elevating the outer rail, will be as per detail plans furnished for same. When mud mills are used for supporting either framed trestle bents or jack stringers, the soil shall be removed and a foundation of gravel placed, all of such a depth and rammed in such a manner as the Engineer shall direct, without cost to the Company.

Inspection. All rejected materials must be removed from the Company's premises within 5 days from the date of notice to do so.

Payment. The price bid shall include the framing and erection of all the timber embodied in the finished structure (exclusive of the piling, which shall be paid for as specified under "Piling"). The price shall include the cost of hauling from the railroad station, or wharf, of all the lumber, spikes, bolts, washers, etc., furnishing, framing, and erection; all to be done as shown on the plans and described in the specifications.

PILING

Quality and Dimensions. All piles shall be of young, straight, sound, and thrifty white oak, yellow pine, or other timber equally good for the purposes, acceptable to the Engineer. Piling shall be treated with creosoted oil where shown on the plans, and shall not be less than 14 inches in diameter, 2 feet from the butt.

Piles having a length of 60 feet and over shall have a diameter at the point of not less than 7 inches.

Piles having a length of from 40 to 60 feet shall have a diameter at the point of not less than 7½ inches.

Piles having a length of from 30 to 40 feet shall have a diameter at the point of not less than 10 inches.

Piles of less length than 30 feet shall have a diameter at the point of not less than 10 inches, exclusive of the bark. When sawed off, at no point shall they be of greater diameter than 18 inches. They shall be so straight that a line stretched

from the center of the pile at the butt to the center of the pile at the tip will not leave the center of the pile at any point more than 2 inches for piles 20 feet long, 4 inches for piles 30 feet long, 6 inches for piles 40 feet long, and 8 inches for piles 50 feet long. No short or sharp bends will be allowed. All knots shall be trimmed close to the body of the pile, and the bark peeled before placing the pile in the leads of the driver.

Payments. Piling shall be paid for at the price per linear foot, in place, given in the proposal. No part of the pile shall be paid for except that which remains in the work.

Driving Piles. All piles shall be driven to a depth to secure a penetration into the underlying material satisfactory to the Engineer. It is probable that this result can best be obtained by the use of a water jet at the bottom of the pile, the nozzle of same being carried below the point of the pile. After piles shall have been jetted to a sufficient depth to secure the required stability, they shall be driven until they do not move more than one-half inch under the blow of a hammer weighing 2000 pounds, falling 25 feet at the last blow. If required, 5 additional blows from the same height shall then be delivered and the pile shall then be considered as driven, provided the one-half-inch limit be not exceeded under any of the last 5 blows. They must be driven vertically, excepting where batter piles are shown, and at regular distances apart from centers, transversely and longitudinally, as required by the plans, or directions of the Engineer; they must be cut off squarely at the butt, and be well sharpened to a point or cut squarely off, as the Engineer may direct, and the heads shall be bound with iron hoops, of such dimensions as he may direct, both without additional cost to the Company. Where batter piles are required, they shall be driven at the angle shown on the plans. All piles when thus driven to the required depth, shall be cut off square and horizontal at the proper height given by the Engineer, and only the actual number of linear feet of the pile left for use in the structures, after being driven and sawed off, shall be paid for. No splits or imperfect piles will be accepted. A follower of approved description shall be used when directed by the Engineer. Any open space that may be left around the driven piles shall be thoroughly filled with beach sand.

After creosoted piles have been driven and cut off to the proper height, the heads shall be treated to an application of hot creosote oil of quality as herein specified, followed by a further application of asphalt thinned with oil.

Price. The price shall include the hauling of the piles from the point of delivery to the point where they are to be driven, and shall be per linear foot of piling actually left in the work.

Specifications for Standard Piling *

Quality of Material. Piling shall be of white, post, or burr oak, tamarack, Norway or Southern long-leaf yellow pine, white or red cedar, red or yellow Douglas fir, or red or swamp cypress.

All piling shall be cut from sound live trees of slow growth, firm grain, and free from ring shakes, decay, large unsound knots, or other defects that will impair their strength or durability. They shall be butt cut above the ground swell, and be uniformly tapering from the butt to the point. They shall be so straight that a line stretched from the center of the pile at the butt to the center of the pile at the point, will not leave the center of the pile at any point more than 2 inches for piles 20 feet long, 4 inches for piles 30 feet long, 6 inches for piles 40 feet long, and 8 inches for piles 50 feet long. No short bends will be allowed. The ends shall be cut square and all bark, branches, and knots shall be trimmed off, finishing the pile in a workmanlike manner. The bark must be peeled before placing the pile in the leads of the pile driver.

Diameter of Piles. The diameter of piles after the bark is peeled from them shall be as follows for the different kinds of timber:

	White Oak	Southern L.L.Y. Pine	Norway & Tamarack	White Cedar	Red Cedar	Red or Yel. Doug. Fir.		Red or Swamp Cypress
						Under 40′	Over 40′	
Maximum diameter at butt		16″	18″			18″	20″	16″
Minimum diameter at butt		14″	14″	14″	12″	14″	16″	14″
Min. diameter 6′ from butt	12″							
Min. diameter at point less than 30′ long	10″	10″	10″	9″	9″	10″		10″
Min. diameter at point from 31′ to 39′ long	9″	10″	9″	8″	8″	10″		9″
Min. diameter at point 40′ and over in length	8″	10″	9″	8″	8″		8″	8″
Per cent of heart		80				75	75	100

Driving Piles. All piles shall be driven into the hard bottom until they do not move more than one-half inch under the blow of a hammer weighing 2000 pounds, falling 25 feet at the last blow, or a hammer and fall producing the same mechanical effect.

If required, five additional blows from the same height shall be delivered, and the pile shall then be considered as driven, provided the one-half inch limit be not exceeded under any of the last five blows. They must be driven vertically except when batter piles are shown, at regular distances apart from centers, transversely and longitudinally, as required by the plans or directions of the Engineer.

They must be cut off squarely at the butt, and be well sharpened to a point and, when necessary in the opinion of the Engineer, shall be shod with approved wrought-iron shoes and the heads bound with iron hoops, of such

* Summary of Specifications for Piling adopted by the American Railway Engineering and Maintenance of Way Association.

dimensions as he may direct, both without additional cost to the Company. When batter piles are required they shall be driven at the angle required on the plans, and shall require but slight bending before framing. All piles when thus driven to the required depths, shall be cut off truly square and horizontal at the proper height, and shall be so trimmed as to leave no horizontal projection outside the cap. Only the actual number of linear feet of the pile left for use in the foundation or trestle, after being driven and sawed off, shall be paid for. No split or imperfect piles will be accepted.

TREATMENT OF TIMBER WITH CREOSOTE

Quality, Size, etc., of Timber. *Bridge Timber.* All bridge timber shall be of Georgia or Florida long-leaf yellow pine and must be inspected under the Interstate Rules of 1905 for the classification and inspection of yellow pine lumber, to meet the requirements of either Prime Inspection or Merchantable Inspection, as may be necessary to meet the conditions and which will be determined in advance when the order is placed. All bridge timber shall be treated with dead oil of coal tar, and each piece after treatment must contain not less than 12 pounds of oil per cubic foot.

Piles. All piles shall be of young, straight, sound, and thrifty Carolina or short-leaf yellow pine, acceptable to the Engineer, and shall be treated with creosote oil as herein specified as to quality and method of treatment. They shall be not less than..... inches in diameter.....feet from butt, and shall have a diameter at the point of not less than.....inches, exclusive of the bark. Both the outside and inside bark shall be thoroughly and carefully removed before the piles are placed in the cylinder for treatment. When sawed off, at no point shall they be of greater diameter than 18 inches; they must be so straight that the pile at no point deviates by more than one-half of its diameter from a straight line, and gradually tapers from end to end. The ends must be cut square and all branches and knots trimmed off to finish the pile in a workmanlike manner. All piles shall be treated with dead oil of coal tar, and each pile after treatment must contain not less than 12 pounds of oil per cubic foot.

Crossties. All crossties shall be of Georgia or Florida long-leaf yellow pine of such quality as shall satisfy the requirements of Standard Inspection according to the Interstate Rules of 1905. They shall be.....long,.....thick, and.....in width. Ties shall be sawed or hewn smooth on four sides, with the faces true and parallel; free from deep score marks, splinters, and other injurious inequalities of surface; and shall be sawed square. The variation in thickness shall not be more than one-half inch, and in length not more than 1 inch. Ties shall be treated with dead

oil of coal tar and each tie after treatment must contain not less than 10 pounds of oil per cubic foot.

Switch Ties. All switch ties shall be of Georgia or Florida long-leaf yellow pine of such quality as shall satisfy the requirements of Standard Inspection according to the Interstate Rules of 1905. Switch ties shall be treated with dead oil of coal tar, and each piece after treatment must contain not less than 10 pounds of oil per cubic foot.

Treatment. *Steaming.* It is preferred that the timber shall be thoroughly air seasoned for 90 days before treating; that which is not thoroughly seasoned shall be steamed. To obtain the removal of sap and water and to open the pores of the wood, the timber shall be subjected to the direct action of live steam admitted to the treating cylinder under a pressure of not less than 20 pounds and not to exceed 30 pounds per square inch, as recorded by a steam gage attached to the treating cylinder (which pressure must be sustained within the cylinder for from 30 to 50 minutes). The pressure and time of steaming shall be regulated according to the size and condition of the stock used. The time of steaming shall range from 2 to 6 hours, depending on the character and condition of the timber. The cylinder shall be frequently drained by a valve located at its lowest point. The timer used in any one cylinder charge shall all be of the same class, kind, and quality; that is to say, any one cylinder charge shall be exclusively long-leaf, short-leaf, or loblolly pine, and in no case shall these be mixed.

Injection. When, in the opinion of the Engineer, the timber shall have undergone the steaming process for a sufficient length of time, a vacuum shall be created in the cylinder, the temperature being at all times maintained above the boiling point. A vacuum of from 22 to 26 inches shall continue for from 1 to 6 hours, or until the timber has been thoroughly seasoned and no sap or moisture comes from or remains in the cylinder. During this vacuum process the lumber in the cylinder shall be kept at a temperature of about 175° F. by means of steam coils in the cylinder. While the above vacuum is maintained, the oil, as herein specified, shall be admitted to the cylinder under pressure at a temperature of at least 175° F. and the pressure pump shall be kept in operation until the timber has absorbed the prescribed amount of oil per cubic foot, the same to be determined by such system of measurements and tests as the Engineer shall elect. When the cylinder is nearly full, the valve leading to the vacuum pump shall be closed and the oil slowly forced into the cylinder and the pressure maintained until the wood has absorbed the required amount.

If, in the judgment of the Inspector, a better and more satisfactory treatment can be obtained by breaking the vacuum before filling the cylinder with the creosote oil, and then forcing the oil into the wood with pressure, the Inspector shall have the power to order such method of injecting with creosote oil. This is not intended to obviate or relieve the necessity of applying the final air pressure as hereinafter provided.

After releasing the pressure and emptying the cylinder of oil, air pressure in excess of the oil pressure shall be applied, to render the penetration more perfect and make the outside of the timber cleaner and drier.

The entire charge of timber shall absorb the oil to a depth of not less than 2 inches on all exposed surfaces. Such pieces as fail to receive the required penetration shall be returned to the chamber with a subsequent charge for further treatment.

Oil. The oil used in treatment shall be a dead oil of coal tar commonly known as creosote oil, and shall be the best obtainable grade of coal tar creosote. Its specific gravity shall not be less than 1.04 at 35° C. It shall not contain more than 2½% of water. Compensation, by the injection of a proportionately larger amount of oil into the timber being treated, for a greater amount of water in the oil will not be allowed. The oil shall be completely liquid at 38° C. and must be free from suspended matter. It shall yield not more than 10% by weight when distilled up to 210° C. Between 210° and 235° C., the distillate by weight shall not be less than 25% or more than 30%, and at least 30% weight shall not distill below 260° C. The oil must be free from acetic acid and acetates, and the residue above 355° C., if it exceeds 5% in quality, must be soft. The sample of oil for test shall be taken from the side and near the middle of the treating cylinder, after the pump has begun the injection of oil. During the analysis of the oil, the thermometer bulb shall be kept about one-eighth of an inch above the surface of oil in the retort.

Loading. The timber shall be piled on the treating trucks in such manner as to give all sides of the timber access to the creosote oil. All pieces treated in any one cylinder load shall be of uniform character and sectional dimensions. Both the outside and inside bark shall be carefully removed from all piling before it is placed in the treating cylinder. If any of the timber, furnished under contract, is acceptable to the purchaser and contains less than the prescribed amount of dead oil of coal tar per cubic foot, the Contractor agrees to make an allowance on each piece of timber equal to the difference in the quantity of oil

contained in each piece and the prescribed amount per cubic foot at the rate of ten (10) cents per gallon.

Inspection. The timber before treatment and the method of treatment shall be subject to the inspection of such inspectors as shall be appointed by the Purchaser, and he shall be afforded, free of charge, every facility for performing such inspection. The Contractor shall, upon the request of the Inspector, furnish the Purchaser with samples of the oil being used, and shall allow the Inspector at any time to take such samples of oil for testing as he may require. The Contractor shall grant to the Purchaser or his inspectors access at all reasonable times to all of the records of the works pertaining to the treatment of timber for the Purchaser.

The Contractor shall provide and install such apparatus as is necessary to enable the Inspector to determine the amount of oil absorbed by the timber, this amount being based upon gage readings taken before the introduction of the oil into the cylinder and after the forcing back of the oil after treatment; also to determine the various temperatures and pressures required, and to examine the products of the vacuum.

The Inspector shall be allowed, if he desires, the use of the laboratory and the apparatus therein for making such distillation tests as he may require, and for the inspection of such operation in connection with the work.

Should he desire to ascertain the depth of penetration of oil in any timber, a five-eighths-inch auger must be furnished to enable him to bore such timber, and he shall be at liberty, if he so desires, and without cost to the Purchaser, to saw in two one tie from each 500 ties under treatment, to ascertain the quality of the work being done.

Inspection and acceptance, or lack of inspection and lack of acceptance or rejections, on the part of the Purchaser, or his inspectors, shall not be any bar to subsequent rejection for cause.

Method of Distillation. In making the tests the oil shall be distilled according to the common method; that is, using an 8-ounce asbestos-covered retort with standard thermometer bulb one-half inch above the surface of the oil; the creosote calculated on the basis of the dry oil shall give the distillates as above required at the various temperatures.

IRON WORK FOR TIMBER TRESTLES

Iron Work. All bolts and nuts shall be of wrought iron. Wrought iron shall be double rolled, of the best quality of American refined iron, tough, fibrous, ductile, and capable of standing

a tensile strain of 48,000 pounds per square inch before rupture, and an elongation of 22% in 8 inches, with fracture wholly fibrous. It shall bend cold with the fiber through 180° around a diameter not greater than twice the thickness of the specimen tested, without fracture on the outside of the bent portion. When nicked and bent, the fracture shall show at least 90% fibrous.

Cast Iron. All castings shall be tough, close-grained gray iron, sound, smooth, clean; free from cold shuts, blowholes, blisters, and all defects; and shall be made accurately to the dimensions shown on the plans. Sample pieces, 1 inch square, cast from the same heat of metal in sand molds, shall be capable of sustaining, on a clear span of 12 inches, a central load of 2400 pounds when tested in the rough bar. A blow from a hammer shall produce an indentation on a rectangular edge of the casting without flaking the metal.

Cast Washers. Cast washers shall be of cast iron. The diameter shall be not less than $3\frac{1}{2}$ times the diameter of the bolt for which it is used, and its thickness shall be equal to the diameter of the bolt; the diameter of the hole shall be one-eighth inch larger than the diameter of the bolt.

Wrought Washers. Wrought washers shall be of wrought iron or steel; the diameter shall be not less than $3\frac{1}{2}$ times the diameter of the bolt for which it is used, and not less than one-fourth inch thick. The hole shall be one-eighth inch larger than the diameter of the bolt.

Bolts. Bolts shall be made with square heads, standard size, the length of the thread to be $2\frac{1}{2}$ times the diameter of the bolt. The nuts shall be made square, standard size, with threads fitting closely the thread of the bolt. All threads shall be cut according to the United States standard. Drift bolts shall have square heads and chisel points.

Spikes. Steel wire spikes may be used up to a length of 6 inches; where greater lengths are required, wrought iron or steel shall be used.

TRACK LAYING

HANDLING SUPPLIES

Work to Be Performed. The work to be performed will consist of furnishing all material (except rails, angle bars, bolts, frogs, mates, switches, spikes, and electrical bonds and ties, which will be furnished by the railroad company, f. o. b. cars on siding at.....), all tools, machinery, and apparatus; the doing of all the work necessary for the efficient construction

of a railroad with passing sidings, as called for by these specifications and the requirements of the Engineer; and in accordance with the plans and drawings, leaving the whole work in a finished and perfect condition in every respect, from a point near.....at.....on the.....Railroad, known as station....., to a point in....., near the....., as located over the right of way of said railroad company for a distance of .....miles.

Delivery of Materials. The railroad company will furnish the material above specified, f. o. b. cars on siding at..... Upon the arrival of the carloads of material, the railroad company will turn over to the Contractor the bills of lading covering the material, and the Contractor will then be held responsible for the inspection as to count and accounting for the material.

Unloading Cars. The Contractor will be required to remove from the cars, promptly on their arrival, all material, and will be held responsible for any demurrage arising from his failure promptly to remove the material from said cars. The materials shall be piled in such a manner and at such points as the Engineer shall prescribe.

Sub-Delivery. The Contractor will be required, at his own cost and expense, to furnish and provide all labor and appliances required for handling and sub-delivery of all materials furnished him by the Company.

Material on Hand. The Contractor must at all times keep such a record of materials on hand, and of their location, that he will know whether he is supplied with sufficient material to complete the work in accordance with the specifications, as no additional time will be allowed the Contractor to complete his work by reason of his learning at too late a time that additional material is required to complete the work within the time specified. All materials delivered along the line of the proposed railroad before the completion of the grading shall be placed outside the line of the slope stakes.

PREPARING ROADBED

Grading. Before a tie is laid, and just before the track laying is begun, a small gang of experienced graders shall go ahead of the tie layers with the engineer corps, who will give the grades and the superelevation of the curves.

The graders, in charge of a competent foreman, must be provided with the necessary sight boards, and other tools and implements required, and must carefully level off the surface of the

roadbed to the grade stakes set for same, and no indifferent leveling of grading will be allowed.

No blocking up under crossties, with timber or broken rock, will be allowed.

LAYING THE TRACK

Ties. The ties shall be spaced so as to give 16 ties to each 33 feet of rail. At rail joints the ties shall be spaced 18 inches between centers. On tangents they shall be laid truly at right angles to the rails, while on curves they shall be laid radially, and the ends lined up parallel with the rails on the side of the track which the Engineer may direct. The ties must not be notched under any circumstances, but should they be twisted, they must be made true with the adz, in order that the rails may have an even bearing over the whole breadth of the tie.

Rails. *Bending.* If the rails are bent in handling they shall be perfectly straightened before being laid in the track. Rails used on sharp curves shall be curved in a bending machine accurately and truly to ordinates, which will be furnished by the Assistant Engineer. In no case will forcing, springing, or sledging the rails be allowed.

Laying. To avoid bad joints and short rails, the track laying shall proceed from the ends of the road and it shall be continuous for the entire length of the same. The rails shall be laid to the stakes given by the Engineer, and on curves they must be bent to the proper curvature before being laid upon the ties. On tangents the rails shall be level, and on curves the proper elevation must be given to the outer rail and carried uniformly around the curve. This elevation shall be commenced from 50 to 200 feet back of the point of curvature as directed by the Engineer and, depending on the degree of the curve, shall be increased uniformly to the latter point, where the full elevation is attained. On curves sharper than 4 degrees, an additional spike shall be put on the outside of the outer rail.

Spiking. There must be four spikes to each crosstie—two inside and two outside of the rails; they must be driven with a proper amount of "stagger", so as to avoid splitting the crossties; and the two inside spikes must be driven in the same edge of tie, so as to keep the tie at right angles to the track. In driving spikes on the gage side, care must be taken to place the gage at right angles with the rail. The spikes must be driven as nearly perpendicularly as possible; and not more than 4 inches from center to center of spike on a line parallel with the rail; and no blow must be struck after the head of the spike is fairly down on the rail flange. Great care must also be taken not to

strike the rail, and none but experienced and expert spikers must be employed on the work.

Joints. The joints of the rails shall be exactly at the middle of the joint ties, and the joint on the one line of rail shall be opposite the middle of the rail on the other line of rail of the same track. A distance must be left between the ends of the rails to allow for expansion; in winter five-sixteenths of an inch, in summer one-sixteenth of an inch. The use of iron shims for securing this spacing will be imperatively insisted upon, and the Contractor must provide himself with a sufficient quantity of them, of the thickness above specified. Joints on or within 4 feet of cattle guards or open culverts must be avoided wherever possible. Care must be taken to place the angle bars squarely in position. The head of the bolts must be struck with a 2-pound hammer, while pressure is applied with a 30-inch wrench to tighten the bolt. The gage of the track shall not vary more than one-sixteenth of an inch from the standard of this railroad, which is 4 feet 8½ inches. The gage shall be widened on curves, if directed by the Engineer, but not otherwise. Such elevation shall be given to the outer rail on curves as the Engineer shall direct.

Bonding. All the joints of the track rails shall be single bonded with the Improved Open Double Electric Protected Rail Bonds having a capacity equal to No. 0000 B. & S. gage round copper wire.

The rail drilling to receive the bonds must be performed on the ground and all holes carefully cleaned out and the bond terminals thoroughly polished so as to form a perfect contact of the entire circumference of the terminal of the bond with the rail. Care must be taken not to disturb the bond after it is put in place.

Special Work. In laying switches, frogs, mates, and other special work, care shall be taken to place them accurately in the position determined by the Engineer. The gage at switches, on tangent, shall be one-sixteenth of an inch tight. If the special work does not appear to fit, no attempt whatever shall be made to force it, except by direction of the Engineer. Special work shall be laid on ties specially provided for the purpose, which shall be so laid as to give a firm and a continuous bearing upon the ballast. Particular attention should be given to having them well lined up to avoid low joints at the head blocks of switches. Guard rails shall be used on curves sharper than 9 degrees, and at turnouts; they shall be of proper length, and properly adjusted and securely fastened. Plans of switch stands, frogs, and fixtures will be furnished, showing minor details of placing in position, etc., or instructions of the Engineer shall be followed.

Joints Tightened. After the surfacing has been completed the joints shall be carefully gone over and tightened up as described under "Joints".

Maintenance Before Acceptance. Before any construction car or engine is allowed to run over the rails, the track must be lined and so firmly tamped to a good level that there shall be no chance of straining or bending the rails. Material for tamping must not be dug out of embankments or bermes, nor shall any material be taken from the side slopes of cuts in such way as to disfigure them. When track material is being hauled by the Contractor's trains over track already laid, such track shall be kept in good line and surface by the Contractor. The Contractor shall maintain and keep the track in good repair until the same is accepted, and no length of track shall be accepted and taken off the hands of the Contractor, except at the option of the Engineer, until the whole shall have been completed.

Measurement of Track for Payment. In making payment for track laying, all measurements shall be made per linear foot of single track, measured on the center line; and where turnouts occur the measurement shall be made once on the main track and again on the turnout from the point of switch of the turnout to be measured. At steam or electric road crossings, measurements shall be made once on the main track and again on the line of the intersecting road. The price for track laying shall include the unloading and hauling of materials; the placing of ties, rails, angle bars, and special work; and the bending, bolting, spiking, lining, and ballasting of the same.

BALLASTING

Gravel Ballast. Gravel shall be clean, free from clay, earth, loam, and stones larger than would pass through a 2½-inch ring in any direction; it must not contain more than one-third sand, and shall be subject to the inspection and acceptance of the Engineer.

Cinder Ballast. Cinder ballast shall be free from all objectionable materials and of a quality approved by the Engineer.

Broken Stone. Stone ballast shall consist of clean broken granite, trap, or other hard stone, to be approved by the Engineer, and must be crushed so that its greatest dimension will pass through a 2½-inch ring.

Lining. After the rails have been spiked to the ties, the entire track must be raised to the finished grade and carefully aligned to the stakes given by the Engineer. The space under the ties must then be filled with ballast of approved quality, satisfactory to the Engineer. Care must be taken in raising the

track and tamping same not to deform the rails, splice bars, or bonds. The space between the ties shall be filled with ballast to the lines and slopes as shown on the standard section of roadbed.

Tamping. The ties shall be tamped from 15 inches inside the rail to the ends of the ties; if possible, tamp the ends of the tie outside the rail first and allow the material train to pass over it before tamping the inside of the rail, giving special attention to tamping under the rail; tamp the center of the tie loosely with a shovel when using gravel or cinder ballast; where stone ballast is used, do not tamp the center of the tie. Ties must be tamped solidly from the end, using tamping bar or tamping pick, as the Engineer may direct. Care must be taken not to disturb the roadbed. When gravel ballast is used it shall be firmly packed or rammed between the ties to the prescribed slope, so that it will readily shed the water and shall not be banked above the bottom of the ends of the ties; a space of not less than 1 inch shall be left between the top of the ballast and the base of the rail to allow the water to run off readily, care being taken to carry the ballast in the middle of the track to the full height shown in the standard drawings.

SURFACING

Every care shall be taken to maintain the crown of the roadbed in the center as shown on the standard drawings and, when the condition of the roadbed, on account of washing or settlement, does not allow of the exact depth of ballast beneath the ties, the Contractor shall make the necessary excavation or fill without cost to the Company. Should any material for ballast be taken out of the side slopes of cuts, it must be done in such a way as not to disfigure them. Material for ballast shall not be taken from embankments. In surfacing, the level board shall be used, at head, at joints, at quarters, and at centers. After the completion of surfacing, all materials that shall have been allowed to accumulate in the ditches on either side of the roadbed, shall be removed, and the road properly ditched and cleaned up. All necessary cross drains shall be laid at proper intervals.

GENERAL SPECIFICATIONS FOR CROSSTIES

Timber. Crossties will be accepted of the following varieties of timber: Oaks of the various kinds known as white, rock, and post (no red oak will be received), second growth white chestnut, cherry, maple, butternut, tamarack, and yellow pine of the long-

leaf, Southern hard-pine variety, cut from untapped trees and grown not north of South Carolina.

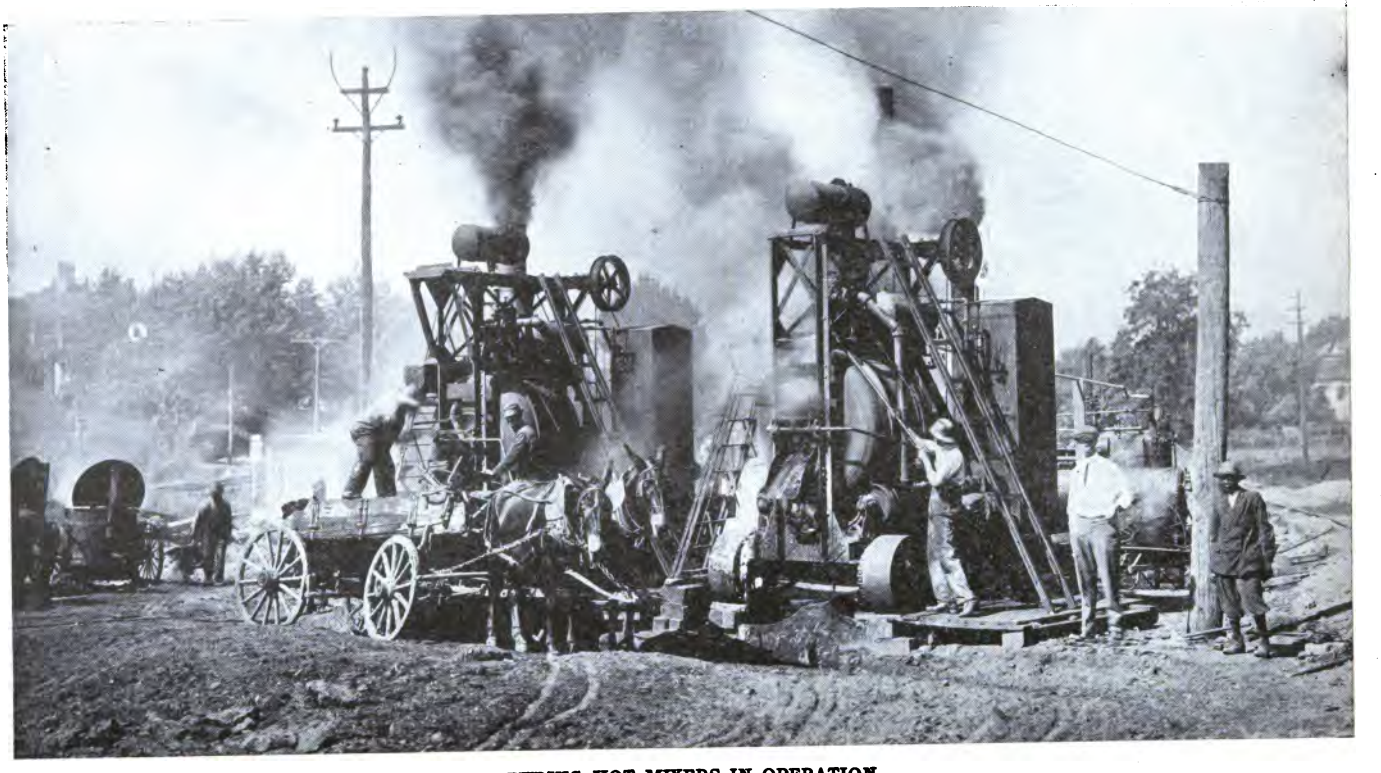
Sizes. *First Class.* First class crossties shall be 8½ feet in length, 7 inches in thickness, and not less than 7 inches in width of face on both sides at the small end.

Second Class. Second class crossties shall be 8 feet in length, 6 inches in thickness, and not less than 6 inches in width of face on both sides at the small end; and in each class there must be at least one-fourth of the whole number that are not less than 9 inches in width of face.

Manufacture. All ties must be made from sound, thrifty, live or green timber; free from loose or rotten knots, wormholes, dry rot, wind-shakes, splits, or any other imperfections affecting the strength or durability of the timber.

Not more than 1 inch of sapwood will be allowed on the edges or corners, and none at all on either face of the ties. They must be hewed or sawed with the faces perfectly true and parallel, of the exact thickness specified. The faces must be "out of wind", smooth, and free from any inequalities of surface, deep score marks, or splinters. The ties must be cut or sawed square on the ends to the exact lengths given; they must be generally straight in all directions; and they will not be accepted if more than 3 inches out of straight in any direction; and they must be peeled or stripped entirely free from the bark before being delivered. No split ties will be accepted under any circumstances, and "culls" only at the option of the Company and at such prices as may be agreed upon from time to time.

Delivery. All ties delivered along the line of the railway must be stacked up in neat square stacks of 50 ties in each, with alternate layers crossing each other, and on ground, wherever possible, as high or higher than the grade of the railroad, and in such position as to admit of being counted and inspected with ease and facility. Ties delivered at suitable and convenient places, acceptable to the Company, will be inspected, and bills made for all ties received and accepted up to the last day of each month, and payment will be made for same on or about the _____day of the succeeding month.



KOEHRING HOT MIXERS IN OPERATION

Courtesy of Koehring Machine Company, Milwaukee, Wisconsin

CIVIL ENGINEERING SPECIFICATIONS AND CONTRACTS

PART II

TYPICAL ILLUSTRATIVE SPECIFICATIONS
(Continued)

SPECIFICATIONS FOR OVERHEAD CONSTRUCTION OF AN ELECTRIC RAILWAY

Materials Furnished by the Company. The Company will furnish f. o. b. cars.....City, all poles and trimmings, span wire, trolley wire, and overhead construction materials with the exception of solder, tape, and paint:

Contractor's Obligations. The Contractor shall remove from railroad stations all poles and overhead materials, and shall store and protect same, and be responsible for their safe keeping. The Contractor shall be responsible for demurrage accruing from neglect to remove the materials from the cars promptly. The Contractor shall furnish all labor, tools, and appliances for the complete erection of the overhead construction.

Poles. The poles shall be of iron, 28 feet long, weighing approximately 600 pounds. They shall be made of 7-, 6-, and 5-inch section of pipe, telescoped and swedged together.

Setting. The Company will furnish permits for the erection of poles located as shown on the plans. The Contractor shall set poles 6 feet in the ground in 1-3-6 Portland cement concrete, in holes not less than 18 inches in diameter. Poles shall be set with a rake of 8 inches, on straight track, away from the line of strain. On curves, poles shall be set with a rake of 14 inches. In case water is found in pole holes, the lower portion of the hole must be protected by sinking a barrel, or by other similar precaution. Before poles are placed in concrete, they shall be given one coat of approved asphalt paint for the lower 7 feet. Asphalt paint shall be furnished by the Contractor.

All pavements, awnings, water, gas, or sewer pipes, or other structures damaged during the erection of the poles must be

replaced in as good condition as found, at the Contractor's expense.

On completion of work, the poles shall be painted with one coat of lead and oil paint, of approved color. The paint shall be supplied by the Contractor.

Span Construction. The entire line shall be of span construction. The span wires shall consist of seven-strand five-sixteenths-inch galvanized steel cable; and the spans shall be secured to the poles by double-bolt pole rings. At each end of the span wire there shall be put in a globe strain insulator which shall connect with the outer bolt of the pole band. The spans shall be drawn taut and the ends shall be made up to the strains. At all curves the pull-off wires shall be secured to an anchor pole with a heavy band; a turnbuckle and a heavy insulated strain shall be put in between the pull-off wires and the pole. Each pull-off wire shall have in addition to this insulation a giant strain insulator at the pull-off fitting. Wherever pull-off wires cross the main trolley wire, they shall be secured to the cross wire with standard soldered ear and bell insulator.

Trolley Wire. Trolley wire shall be No. 0000 B. & S. gage round copper wire. At terminals wire shall be secured to poles through heavy double strain insulators and bridled to terminal poles. Trolley wire shall be strung tight and shall be at least 20 feet from the track, except at railroad crossings, where it must be 22 feet from the track. At each side of all railroad crossings there shall be installed a strain ear secured to an extra span wire run above regular span wire, with globe strain insulation in the bridle. Trolley wire must be located in the true center of the track on a straight track, and at all curves it must be so pulled over that the trolley wheel on the car will always stay on the wire.

The insulated hangers shall be the Keystone bell type. The ears shall be deep-grooved milled ears, soldered to the wire. Great care must be used in soldering; flux used shall be Yeager soldering salt or its equal.

Frogs and Lightning Arresters. The Contractor shall install all of the necessary frogs over special work; install the necessary insulated crossings at.....Avenue; and install 4 lightning arresters attached to the poles and the necessary single No. 0 B. & S. gage wire in connections from same to the track. These lightning arrester lead wires are to be brought down inside the pole, through a hole bored in the pole below the pavement line, and the wires shall be connected to the cross bond in the track and securely soldered to the same.

Joints. All joints in the trolley wire shall be made with long soldered-copper sleeves.

Strain Guys. The strain guys shall be erected on each side of the curves between.....Avenue and..... Avenue, leading into.....Avenue. Single strain guys shall be placed on each side of each railroad crossing. These strain guys shall lead to the nearest poles and have a globe strain insulator cut in, 2 feet from the strain ear, and also at turnbuckle.

It is the general intention of these specifications that the Contractor shall erect the complete overhead construction ready for the operation of cars.

SPECIFICATIONS FOR A STONE ROAD

Work to be Performed. The work to be performed will consist in furnishing all material, tools, machinery, and labor necessary for the efficient and proper grading of the roadway, side ditches, and side banks; for the laying, spreading, and rolling of road metal; and leaving the roadway complete in every manner, ready for immediate use.

Plans and Drawings. The plan, profile, and cross sections on file in the office of the State Commissioner of Public Roads and at the office of.....County Engineer, ..., show general location, profile, details, and dimensions. The work will be constructed in all respects according to the above-mentioned plans, profile, and cross sections, which form part of these specifications.

Any variation of location, profile, size, and dimensions from that shown on the plans, as may be required by the exigencies of construction, will, in all cases, be determined by the Engineer; but the Contractor shall not, on any pretense, save that of the written order of the contracting parties, deviate from the intent of the plans or specifications.

On all drawings, figured dimensions are to govern in cases of discrepancy between scale and figures.

Grading. Under this head will be included all the excavation and embankment required for the formation of the highway; cutting all ditches or drains about or contiguous to the road; removing all fences, walls, buildings, trees, poles, or other encumbrances; the excavation and embankment necessary for reconstructing cross or branch roads in cases where they are destroyed or interfered with in the formation of the roadway; and all other excavations and embankments connected with or incidental to the construction of the said road.

Excavation. The roadway to the width of..... feet as shown on the plan must be excavated or built to the same

curvature as that of the surface of the road when finished; the grade, from center to sides, must be as shown on plans.

The earth taken from any cut or ditch shall be deposited wherever the Engineer may direct, either within or without the line of the road; but no earth shall be removed from the line of the road without the order of the Engineer.

The grading shall be completed for the full width of the road, from gutter to gutter, before any macadamizing is commenced.

Embankment. Material taken from the excavations, except when otherwise directed by the Engineer, shall be deposited in the embankments, either on the roadway or sidewalks. Rejected or excess material will be used to increase the width of the embankments or deposited in spoil banks or waste piles, wherever and however the Engineer may direct.

When there is not sufficient material in the excavations of the road to form the embankments, the deficiency must be supplied by the Contractor from without the road; the character of said material and place of excavation must be approved by the Engineer; and said material is to be paid for at the same price per cubic yard as specified in the contract for other excavation.

The embankments will be formed in layers of such depth, generally 1 foot, and the material deposited and distributed in such a manner as the Engineer may direct, the required allowance for settling being added.

Slopes. Slopes in both embankments and excavations shall be 1½ horizontal to 1 vertical, unless otherwise ordered by the Engineer.

Roadbed. *Subfoundation.* When the excavations and embankments have been brought to a proper depth below the intended surface of the roadway, the cross section thereof conforming in every respect to the cross section of the road when finished, the same shall be rolled with a 10-ton steam roller until approved by the Engineer. If any depressions form under such rolling, owing to improper material or vegetable matter, the same shall be removed and good earth substituted, and the whole shall be rerolled until thoroughly solid and to above-mentioned grade. Water must be applied in advance of the roller when, in the opinion of the Engineer, it is necessary.

Telford Foundation. After the subfoundation has been formed and rolled, as above specified, and has passed the inspection of the Engineer, a bottom course of stone, of an average depth of 10 inches, is to be set by hand as a close firm pavement; the stones shall be placed on their broadest edges lengthwise across the road in such a manner as to break joints as much as possible, and the breadth of the upper edge shall not exceed 4

inches. The interstices are then to be filled with stone chips, firmly wedged by hand with a hammer, and projecting points shall be broken off. No stone of greater length than 10 inches or width of 4 inches shall be used, except each alternate stone on the outer edge, which shall be double the length of the others and well tied into the bed of the road; all stones with a flat smooth surface must be broken; the whole surface of this pavement shall be subjected to a thorough settling or ramming with heavy sledge hammers, and shall be thoroughly rolled with a 10-ton steam roller. No stone larger than 2½ inches shall be left loose on top of telford.

Macadam. *First Course of Broken Stone.* After the road bed has been formed and rolled as above specified, and has passed the inspection of the Engineer, the first layer of broken stone, consisting of 2½-inch stone, or stone that will pass through a ring 3 inches in diameter, shall be deposited in a uniform layer, having a depth of 6 inches, and rolled repeatedly with a 10-ton steam roller until compacted to the satisfaction of the Engineer. No stone in this course shall be less than 2 inches in length. Water must be applied in advance of the roller, when, in the opinion of the Engineer, it is necessary.

The depth of loose stone in this and all other courses must be measured by blocks the required thickness of the said loose stone. These blocks shall be placed at frequent intervals amid the loose stone when being spread.

Binder Between First and Second Course. On the first course of stone a quantity of.....binder shall be spread in a uniform layer, and the rolling shall be continued until the stones cease to sink or creep in front of the roller; water will be applied in advance of the roller, if ordered by the Engineer. The quantity and quality of this and all other binding shall be at all times subject to the approval of the Engineer.

Second Course of Broken Stone. The second course of broken stone shall consist of 1½-inch stone; that is, every piece of stone shall be broken so that it can be passed through a ring 2 inches in diameter, and no stone shall be more than 2 inches nor less than 1 inch long. This course is to be spread in a uniform layer of.....inches in depth, and rolled until thoroughly settled into place to the satisfaction of the Engineer. Water will be applied, if ordered by the Engineer.

Binder on Second Course of Stone. Binder on this course of stone must be applied in the manner already given for binder on first course of stone as directed by Engineer.

Surface. When the two courses are rolled to the satisfaction of the Engineer, a coat of 50 per cent of three-fourths-inch stone

and 50 per cent of screenings, properly mixed, is to be spread of sufficient thickness to make a smooth and uniform surface to the road; then the road shall again be rolled until it becomes thoroughly consolidated, hard, and smooth.

Rolling shall be done by the Contractor with a 10-ton roller, approved by the Engineer.

Any depressions formed during the rolling, or from any other cause, are to be filled with 1½-inch stone or three-fourths-inch stone, or both, and screenings approved by the Engineer, and the roadway shall be brought to the proper grade and curvature as determined by him.

Water must be applied in such quantities and in such manner as directed by the Engineer.

Manner of Rolling. In the rolling, the operator must start from the side lines of the stone bed and work towards the center, unless otherwise directed. The rolling shall at all times be under the control of the Engineer, who may, from time to time, direct such methods of procedure as in his opinion are required by the necessities of the case.

Quality of Material. All stone must be as nearly cubical as possible; broken with the most approved modern stone-crushing machinery; free from all screenings, earth, and other objectionable substances; of uniform size and of the same kind and quality, or of a kind and quality equally good in every particular as that shown in the Engineer's office. The 1½-inch stone or three-fourths-inch, and the screenings for binder and the final finish must be of the best trap rock, and must be free from loam or clay.

The Contractor must furnish samples to the Engineer of the kind of stone to be used in the work before the opening of the bids.

Shouldering. A shoulder of firm earth or gravel is to be left or made on each side, extending at the same grade and curvature of the road to the side ditches or gutters. This shoulder is to be rolled according to the directions of the Engineer.

Side Ditches or Gutters. The side ditches or gutters are to be excavated as per stakes furnished by the Engineer, in order to give an easy flow of water, so that no water shall be left standing on the road or in the ditches; and for this excavation no extra payment will be made.

Underdrains. Underdrains, if found necessary, shall be constructed by the Contractor (at prices named in bids) of good 4-inch tile, laid upon a board of not less than 1 inch in thickness and 6 inches in width, whenever and wherever the Engineer and Supervisor shall decide; the top of the tile shall be at least .....inches deep, unless otherwise directed by the Engineer;

the joints of the tile shall be covered with salt, hay, or material equally good; and the trench shall be filled with pervious earth.

When directed by the Engineer a stone drain may be used in place of the tile drain. A trench 1 foot wide and 1 foot 6 inches in depth shall be excavated below the subgrade, said excavation to be filled with loose broken stone to a depth required by the Engineer.

No Extra Price. No allowance in measure of depth of pavement will be made on account of any material which may be driven into the roadbed by rolling. The pavement when completed must conform to the grade and the cross sections, and be satisfactory to the Engineer, whose decision shall be final.

No extra work will be paid for unless the price has been agreed upon between the contracting parties, including the State Commissioner of Public Roads, and endorsed upon the agreement, witnessed by the Engineer.

All clay or gravel for shouldering or binder, and all extra hauling, is to be done at the Contractor's expense.

Broad Tire Wagons. All wagons and carts used during the construction for hauling stone, earth, or any other material must have tires not less than 3½ inches in width.

Liabilities of Contractor. *Road Repairs for One Year.* The Contractor shall keep the finished roadway and earthwork in repair for the period of 1 year from the date of its completion and acceptance, during which time he shall be liable for the wear and tear caused by ordinary travel; and, in addition thereto, he shall be liable for as much longer as for any period or periods during said year it shall be out of proper condition. If, during the time of the Contractor's liability, the roadway or any part of the work shall, in the judgment of the Engineer, require repairing, and he shall duly notify the Contractor to make such repairs as are required; and if the Contractor shall refuse or neglect to do so, to the satisfaction of the said Engineer, within 5 days from the date of the service of the notice, then the said Engineer shall have the right to have the work done properly by other parties and pay the expense for the same out of the 5 per cent retained.

Preserving Stakes and Bench Marks. The Contractor shall be required to preserve all stakes and benchmarks made and established on the line of work until duly authorized by the Engineer to remove the same.

Title Stones. The Contractor shall not disturb the position of title stones (the corners of properties adjacent to the road), but where they appear he shall either lift or lower them, under the personal supervision of the Engineer.

Preserving Clear Roadway. The Contractor must also preserve the roadway on which he is working from needless obstruction, and where necessary he must construct safe and commodious crossings, to be maintained in good order. He shall afford all proper and reasonable means for the accommodation of the public, and leave the roadway complete in every manner, ready for immediate use.

Provision for Drainage. If it is necessary in the prosecution of the work, to interrupt or obstruct the natural drainage of the surface or the flow of artificial drains, the Contractor shall provide for the same during the progress of the work in such a way that no damage shall result to either public or private interests. He shall be held liable for all damages which may result from any neglect to provide for either natural or artificial drainage, which he may have interrupted.

Right to Build Bridges, Culverts, etc., and to Suspend Work. The right of the county to build bridges, culverts, lay pipes, or other appurtenances in said road during the progress of the work is expressly reserved, as well as the right to suspend the work or any part thereof during the construction of the same, for the purposes above stated, without further compensation to the Contractor for such suspension than an extension of time for completing the work equal to the length of time his work may have been delayed.

Stopping Work on Account of Weather. The Engineer may stop any portion of the work if, in his judgment, the weather is such as to prevent the work from being properly done. No allowance of any kind will be made for such stoppage, except an extension of the time for the completion of the work as herein provided.

SPECIFICATIONS FOR CONCRETE MACADAM

Cement. The cement shall be first-class hydraulic cement which shall conform in all respects to the Standard Specifications of the American Society for Testing Materials. All cement shall be approved in writing by the State Highway Commissioner, before ordering, and shall preferably be delivered on the work in barrels. The Contractor shall furnish samples of the cement to the State Highway Commissioner, before any of it is used on the work.

Water. Water shall be fresh and clean, free from earth, refuse, and injurious mineral matter.

Broken Stone. Broken stone shall be good hard trap rock or hard blue limestone, clean and sound, broken into sizes ranging

from one-half inch to 1½ inches in diameter. It must be thoroughly cleaned of refuse before using.

Sand. All sand shall be clean, coarse, sharp, and free from loam and vegetable matter.

Concrete Mixing. This concrete shall consist of the above materials properly proportioned for a 1-3-5 mixture, and shall be mixed with a sufficient quantity of water to cause the free mortar to rise to the top of the mass of concrete when tamped into place. It shall be thoroughly mixed by hand or machine and to the satisfaction of the State Highway Commissioner or Engineer in charge.

Placing. After the roadbed has been prepared according to these plans and specifications, a layer of concrete, proportioned as specified above, shall be placed to a depth of 6 inches, on one-half the width of the roadway. The inside edges shall be a dovetailed line as shown on the accompanying plans.

Tamping. The concrete shall be thoroughly tamped with a 25-pound tamper, until free mortar appears on the surface to the depth of 1 inch. The roadway shall then be covered with three-fourths-inch screenings, free from dust, and the same shall be lightly tamped into the free mortar until they are embedded for three-fourths of their depth.

Expansion Joints. If in the judgment of the State Highway Commissioner or Engineer in charge, expansion joints are required, they shall be formed at intervals of every 40 feet, by placing one-half-inch by 8-inch boards in the concrete, at right angles to the center line of the road. These boards shall be properly cut to fit the subsurface and the finished grade of the concrete, and shall be withdrawn from the concrete one hour after placing same, and the space left open thereby shall be filled with hot pitch or some other approved bituminous filler.

Protection of Work. After the concrete shall have been placed it shall be protected from traffic for at least 1 week. While constructing one-half of the roadway, traffic may be permitted on the other half.

Connecting up Work. After one-half of the roadway has been completed, the remaining half shall be laid in the same manner as the first half, making expansion joints continuous with the first half.

No roller shall be permitted on the concrete roadway until 2 weeks after the whole has been completed.

Other Materials. Bids will also be received for other proprietary methods of making a concrete road. If another proprietary method is used it will be placed and the work done in

general under the specifications of the manufacturer in conjunction with the regular specifications of the Department.

Grading, drainage, and telford or macadam foundations, and all other things to be done in the reconstruction must be done under the general specifications of the State Highway Department for road reconstruction.

PAVEMENTS AND CURBING

GENERAL

Removal or Adjustment of Fixtures. The adjustment or resetting of any manholes, fire hydrants, lamp posts, gas stops, telegraph or electric light poles, or other fixtures shall be considered as an appurtenant to the work of paving and repaving; and shall be included as such in the work to be done by the Contractor for the prices bid for paving and repaving. Such adjustment or resetting shall be done by the companies owning them, or, if the property of the City, by the proper municipal Department; but, in either case, it shall be done at the expense of the Contractor.

Granite Blocks on Gravel Base. For granite block paving on gravel base in driveways or gutters, the filling shall be thoroughly compacted to a subgrade 10 inches below the finished grade, and a layer of approved paving gravel spread on it to a least thickness of 4 inches. The blocks shall be placed vertically on edge in straight rows at right angles to the curb line, in close contact, breaking joints; and they shall be thoroughly rammed three times with a rammer weighing not less than 55 pounds; and the finished surface shall conform exactly to the required grade. While the blocks are being rammed, approved paving gravel or sand shall be swept into the joints until they are completely filled. All irregular or uneven surfaces shall be taken up and reset and re-rammed to the proper grade.

Repaving, Resetting Curb, etc. In repaving and in the resetting of curbs and crossing stones, the foundations shall be prepared and all the work shall be done as required for new paving of the same kind. Old materials that may be suitable for replacing may be used only after satisfactory preparation by special permission, and as directed.

Revision of Old Paving. Any revision of old paving, gutter ways, crossings, or curbs, where the new work joins the old work, shall be made as directed, and paid for as provided in the proposal.

Cleaning. Upon the completion of any pavements the Contractor shall clean them promptly of all refuse or surplus materials.

Gutters. The finished grade for the gutters shall generally be 5 inches below the top of the curb, except where given differently on the drawings, or where a change is directed by the Engineer, to insure proper surface drainage.

Crowning or Rise. The crowning or rise of the finished pavements in the driveways shall be uniform from the gutters toward the center of the street; and at the rate of 2½ per cent for granite block or vitrified-clay brick or block pavement, and 2¼ per cent for asphalt pavement; except at intersections, or where the surface drainage demands a different crown, or as may be directed by the Engineer. Gutter and crown stakes must be set every 50 feet. The rise of the sidewalk pavement shall be as directed by the Engineer.

DRIVEWAY PAVEMENTS OF VITRIFIED-CLAY BRICKS OR BLOCKS, GRANITE BLOCKS, AND ASPHALT

Bed. The bed for driveway paving shall be graded from curb to curb, and thoroughly compacted by rolling with a heavy steam roller, weighing not less than 5 gross tons, until the surface shall be accurate to subgrade and parallel to it. The subgrade shall be below the intended finished grade, as follows: for vitrified-clay brick or block pavement, 11 inches; for granite block pavement, 15 inches; for asphalt pavement, 9 inches. All soft and spongy places shall be excavated and refilled with gravel or broken stone before rolling. The use of a horse roller will be allowed where, in the judgment of the Engineer, the use of a steam road roller may be impracticable on account of steep grades or other local conditions.

Concrete Foundation. *Mixing and Laying.* Upon the bed shall be laid a layer 6 inches thick of Portland cement concrete in which is used stone crushed to pass a 1½-inch ring. The concrete shall be rammed with 25-pound rammers until free mortar appears on the surface, which surface shall be parallel to and below the top of the finished pavement, as follows: 5 inches for vitrified-clay brick or block pavement; 9 inches for granite block pavement; and 3 inches for asphalt pavement.

Carting and Wheeling. No carting or wheeling will be allowed on the concrete until covered by paving.

Tests. The concrete foundation shall be capable of sustaining such test as the Engineer shall deem necessary.

Kept Clean and in Advance of Paving. In paving, the Contractor must keep the concrete base to the proper grade or slope at least 100 feet in advance of his paving, and the latter must be laid in sections the full width of the street. The concrete

surface shall be thoroughly cleaned of gravel, rubbish, or covering of any description, before any mortar or sand is placed in which the bricks or blocks are to be bedded.

VITRIFIED-CLAY BRICK OR BLOCK PAVING

Samples for Testing. When paving with vitrified-clay bricks or blocks is required, the Contractor shall submit sample bricks or blocks, and afford every facility for inspection and testing at least 10 days before desiring to use them. The failure of any shipment on any work to meet the requirements may prohibit the further use of the same manufacture on that work.

Size and Quality. The bricks or blocks must be vitrified fire-clay, re-pressed, and especially burned for street paving, not less than 9 inches long, 4 inches wide, and 3 inches thick. They shall be tough, homogeneous, compact in structure, and burned to a uniform consistency. They shall be free from laminations or "fire cracks" or "checks" of more than superficial extent; shall be free from nodules of lime or magnesia or other soluble matter; and shall show no signs of cracking after 48 hours' immersion in water maintained at normal temperature (60-70° F.).

Variations in Size. All bricks or blocks will be allowed a proper shrinkage, but they must not vary more than 3 per cent from the accepted samples. All bricks or blocks so distorted in burning as to lie unevenly in the pavement will be rejected.

Shape. The bricks or blocks must have two or more ribs or projections upon one of the vertical sides, extending from top to bottom; on the opposite vertical side of the brick or block, a groove or channel extending longitudinally from the end of the brick or block, and connecting with a like transverse groove extending across each end; thus serving by contact with the flat side of an adjoining brick or block, to secure a separation, in order that cementing material, flowing into the grooves, may effect a practical encircling of each brick or block, thus keying or locking together the entire pavement.

Testing. Samples of bricks or blocks for testing will be selected at random from actual shipments delivered on the work, and must yield the following results:

Five of the bricks or blocks so sampled will be tested transversely and shall develop an average strength sufficient to sustain a load of 3000 pounds per inch of width. The bricks or blocks in this test shall be supported edgewise, on rounded knife edges placed 6 inches apart; the breaking load being applied centrally. Five bricks or blocks shall be placed in a standard polygonal rumbler (20 inches wide, 30 inches in diameter), together with 10 cast-iron bricks (weighing 6 pounds each), having rounded edges. This rumbler will be revolved

2000 times at the rate of 35 revolutions per minute, and the brick must not show an average loss of more than 18 per cent. The bricks or blocks coming from the rumbler shall be dried for 24 hours at a temperature of not less than 212° F.; and after 48 hours' immersion in water, maintained at a normal temperature, shall not show an absorption of more than 4 per cent.

Laying. The bricks or blocks must be set vertically on edge in close contact with each other, in straight rows across the street, excepting at intersections, which shall be paved at an angle of 45 degrees to the lines of the intersecting roadways, and those in adjoining rows so set as to break joints regularly. No bats or broken bricks or blocks shall be used except at curbs, or adjoining passenger railway rails, where half bricks or blocks must be used to break joints. The bricks or blocks shall be bedded in a layer of Portland cement mortar 1 inch in thickness, freshly mixed, and laid upon the concrete foundation as the placing of the bricks or blocks progresses. They shall be true to the required finished surface when completed, and shall be settled in place, after depositing, by placing a plank upon their tops and ramming the plank as required, with wooden rammers, before the mortar bedding has time to set and as the work progresses.

Grouting. After the bricks or blocks are laid, they shall be grouted with Portland cement grouting, consisting of one part cement to one part clean bar sand, mixed with water to such consistency that it will readily permeate the joints, filling all joints flush with the surface.

Car Tracks. When car tracks cross the deck of a bridge, a line of fitted granite blocks or slag blocks shall be laid on each side of each rail, placed longitudinally or as stretchers. The blocks so used shall be made especially for street paving, shall have beveled edges on top, and be of size and quality to be approved by the Engineer upon the submission of samples properly labeled, the accepted sample to be the standard. All voids under the heads and side bearing flanges, between the webs of the rails and the paving blocks, shall be filled with special molded bricks, thoroughly grouted with Portland cement grout to fill all crevices.

GRANITE BLOCK PAVING ON CONCRETE BASE

Granite Blocks. Granite blocks shall be fitted blocks of approved Eastern granite, with square heads and bottoms, and in sizes from 6 to 6½ inches in depth, 3½ inches in width, 8 to 12 inches in length; 4 inches in width, 8 to 12 inches in length; and 4½ inches in width, 8 to 12 inches in length; to be sorted at the quarries at the above sizes, kept separate, and delivered and set

separately; all the faces of the blocks shall be non-warped and parallel; free from bunches, depressions, and inequalities exceeding one-fourth inch; and no stones shall measure less than the above-named lowest figures.

Laying. Upon the concrete foundation for granite block paving shall be placed a layer 3 inches thick of sharp, approved, coarse New Jersey paving sand, upon which the blocks shall be bedded. Granite blocks shall be properly assorted or gaged, those of the same width and depth to be placed in consecutive rows; blocks differing in width more than one-fourth inch will not be allowed in the same row. They shall be placed vertically on edge in close contact with each other across the street; in straight rows and at right angles to the curbing, except at intersections, where they shall be placed at an angle of 45 degrees to the lines of the intersecting roadways. Blocks in adjoining rows shall be set to break joints by a space not less than 4 inches, and when thoroughly rammed they shall be brought to the exact grade. Joints shall not be more than one-half inch in thickness. At all times during the progress of the work 100 lineal feet of the paving must be laid continually in advance of filling and ramming, to permit the proper inspection of the blocks and the work. The pavement must be laid so that the blocks shall be uniform in width in sections across the full width of the street.

Ramming—Filling Joints. The pavements shall be rammed three times with 55-pound rammers, until no further settling occurs under the ramming. While being rammed the joints shall be kept well filled with dry pebbles. Any blocks that do not conform to the exact grade shall be reset and re-rammed. The pebbles for filling joints shall be quartz, hard, clean, well washed, and not easily crushed, one-eighth to one-fourth inch in diameter, entirely free from dust, dirt, or foreign material, and thoroughly dry when delivered. Immediately after the final ramming the pebbles shall be swept out to a depth of 1 inch from the top of the pavement, and the joints filled with hot paving pitch, applied in liquid form. The pitch must be prepared for paving purposes, so that it can be easily applied in the liquid state when artificially heated, and used to fill the joints thoroughly and not spread over the face of the paving. While the paving pitch is still hot, dry sand shall be spread very thinly over the entire surface of the pavement.

Dry Material. If the weather be damp while the paving is being done, or if the pebbles become wet, they shall be artificially heated and kept hot until they are flooded with the paving pitch.

Tracks. When passenger railway tracks are to be laid, one line of granite blocks shall be laid longitudinally, or as stretchers, along each side of each rail. All voids under the heads and

treads of the rails shall be filled with specially molded bricks, and then thoroughly grouted to fill all voids.

TELFORD PAVING

Roadbed. The bed shall be thoroughly compacted by rolling with a steam roller weighing not less than 5 gross tons, to be parallel to and 12 inches below the finished surface, as given by the District Surveyor.

Sub-Stone Pavement. Upon the bed shall be placed a sub-stone pavement not less than 8 inches deep, consisting of hard approved stones, not less than 12 inches in their longest diameter, placed vertically on edge, in rows square across the driveway, so as to break joints. Projecting points in the subpavement shall be broken off with knapping hammers, after which more stone shall be broken by hand on top and wedged between the pavement stones until all cavities are filled.

Surface Layers. A layer of clean loam, not less than 1 inch thick, shall be deposited on top of the sub-stone pavement. Sufficient crushed stone, crushed to pass a $1\frac{1}{2}$-inch ring, of hard trap rock, free from dirt, shall be deposited on the surface, and rolled with the steam roller previously specified, so that there shall not be less than 4 inches of the crushed stone on top of the foundation stone. After rolling the crushed stone, a covering of fine stone, breaker scale, or screenings of trap rock shall be evenly spread, kept wet, and rolled continuously, until the whole shall be a compact mass, 2 inches above the finished surface as fixed by the Engineer.

CURBING

Materials. Curbing shall be furnished where required by the drawings, and shall be either of steel protected granolithic or of first quality granite. Granite shall be neither laminated nor stratified, shall be hammer-dressed on the face at least 12 inches deep over all of the top surface, and 3 inches deep on the back to receive the sidewalk pavement.

All joints shall be close joints, the full depth and width of the stones.

Dimensions. Curbing shall be either 6 or 8 inches wide on top, as specified; 8-inch curbing shall be 24 inches in depth and 10 inches in width at the base; 6-inch curbing shall be 22 inches in depth and 8 inches in width at the base.

Straight curbing shall not be less than 6 feet in length, and curved curbing shall not be less than 5 feet in length, and no closure shall be less than 4 feet in length. Where curved curbs

are required in excess of 8 feet in length the stone may be in two pieces, either of which may be less than 5 feet in length, but the joint must be in the center.

Foundations. Curbs shall be set upon a solid foundation prepared for them, of coarse gravel or spalls, backed with gravel, all solidly rammed.

The foundation of the sidewalk paving back of the curbs shall be thoroughly compacted by ramming, before the sidewalk paving is laid.

Curbstones set adjacent to inlets shall be square on their ends the full depth of the stones, and the castings for inlet covers, stop boxes, or other municipal or other castings, shall be cut into the curbing, flush with the top of the curb.

Curved Curbs. When curved curbs are placed, the Contractor shall extend the crossing stones to conform to the radius curbs. All curved curbing shall be cut exactly true to the radius ordered, and set to the lines and grades to be obtained from the Engineer.

Joints. All joints of curbing shall be thoroughly back filled, and made water-tight from the base to the top of the curbing with Portland cement mortar, made of one part Portland cement and two parts clean sand, thoroughly mixed into a stiff mortar.

All curbs moved or displaced, or any sidewalks injured or destroyed by the Contractor, or those employed by him, either while grading for the paving or in the handling, placing, or removal of materials, supplies, etc., must be reset, replaced, or repaved in proper manner by the Contractor at his expense.

GRANITE BLOCK PAVING ON SAND BASE

Preparation of Foundation. The spaces to be paved between the lines shown on the plans shall be graded and thoroughly compacted by rolling with a heavy steam roller, weighing not less than 12 gross tons, until the surface shall be brought accurately to subgrade and parallel with and 10 inches below the finished surface. All soft places shall be dug out and filled with paving sand. The subgrade must be compacted to a solid foundation, and must be approved before the block paving is laid. Sharp, approved, coarse paving sand shall be spread upon the foundation, to a depth of at least 4 inches, upon which the blocks shall be bedded.

Granite Blocks. Granite blocks shall be fitted blocks of approved granite $3\frac{1}{2}$ to 4 inches wide, 6 to $6\frac{1}{2}$ inches deep, 8 to 12 inches long, with square heads, smooth faces, and rectangular edges. They shall be subject to inspection and shall be gaged and sorted by men furnished by the Contractor; any blocks re-

jected shall be immediately removed from the vicinity of the work. Those of the same width and depth shall be placed in consecutive rows, and blocks differing in width more than one-fourth inch shall not be allowed in the same row. They shall be placed vertically on edge in close contact with each other across the space to be paved; in straight rows and at right angles to the curbing, except at intersections, where they shall be placed at an angle of 45 degrees to the lines of the intersecting roadways. Blocks in the adjoining rows shall be set to break joints by a space of not less than 4 inches, and when thoroughly rammed they shall be brought to the exact grade. Joints shall not be more than one-half inch in thickness. At all times during the progress of the work, about 100 lineal feet of the paving shall be laid continuously in advance of filling and ramming, to permit the proper inspection of the work. The pavement shall be laid so that the blocks shall be uniform in width in sections across the full width of the space being paved.

Filling Joints. The joints between the blocks shall then at once be filled with paving sand and shall be rammed three times with 55-pound rammers until no further settling occurs under the ramming. While being rammed the joints should be kept well filled with paving sand. Any blocks that do not conform to the exact grade shall be reset and rammed.

Payment. Payment will be made for this paving at the price per square yard given in the proposal, which price shall include everything except such excavation as may be necessary for preparing the subgrade.

ASPHALT PAVING

Samples to be Submitted. If asphalt pavement is to be laid, the Contractor shall submit to the Commissioner of Highways samples of the materials he intends to use, together with certificates and statements as follows:

(1) Specimens of asphalt and asphaltum, with a certificate stating where the specimens were mined.

(2) A specimen of the asphaltic cement, with a statement of the elements of the bituminous cements used in the composition of the paving surface.

(3) Specimens of sand intended to be used.

(4) Specimens of pulverized carbonate of lime, granite, or quartz intended to be used.

(5) A certificate, if the material proposed to be used has not heretofore been used in the City of....., showing some other locality where pavement of such material has been laid, its area, date of acceptance, which must have been at least 2

years previous to the issuance of the certificate, and showing that said pavement has worn well and satisfactorily; all to be signed and acknowledged by the chief municipal officer having charge of said work in the city or cities where such pavement has been laid.

Such specimens, certificates, and statements must be, in the judgment of the Engineer, equal in all respects to similar conditions exacted by the Department of Highways for other asphalt pavement in the City of.....

Subgrade for Asphalt. The backfilling on the top of the trench shall be of clean gravel or sand, or other wholesome earth, free from all spongy or vegetable material; and thoroughly rolled with a roller weighing not less than 10 tons, so that the top of the filling is parallel to the crown of the street and 9 inches below it; except beneath the stone block pavement adjoining rails, manhole heads, and stopcock boxes, where the depth below the finished grade shall be 13½ inches. When the roller cannot reach every portion of the roadbed, the bottom shall be rolled by a small roller, or tamped, as directed by the Engineer, and water shall be sprinkled on such bottom when required. Upon the foundation thus prepared, there shall be laid a bed of hydraulic cement concrete 6 inches in thickness, and made as follows:

Cement. All cement must be of the best quality, of fresh-ground best American Portland cement, and shall be tested and approved by the Engineer before being used.

Portland Cement Concrete. Concrete shall be composed of 1 part of cement, 3 parts of clean sharp sand, and 7 parts of broken stone; or 1 part of cement, 3 parts of clean sharp sand, 4 parts of broken stone, and 3 parts of pebbles by measure.

Mixing. The cement and sand shall be mixed dry; the broken stone having been first wetted shall then be added and the mass turned over, with the addition of the necessary water, and worked until the broken stone is completely incorporated.

Pebbles. The pebbles shall be hard, clean, free from sand, screened and washed, and of a size that has passed a sieve of 1½-inch mesh and rejected by a three-fourths-inch mesh.

Broken Stone. The broken stone shall be solid trap, limestone, or granite, free from dust or dirt, and of a graded size not larger in any dimension than will pass through a 2-inch ring; and it shall be crushed and screened before being brought upon the work; and no crushing shall be done on the work.

Concrete to be Rammed. The concrete shall be placed in proper position and there rammed with wooden rammers until thoroughly compacted; the surface shall be 3 inches below

the grade of the top of the finished pavement and exactly parallel thereto.

The concrete foundation shall be capable of sustaining such test as the Engineer shall deem necessary.

No carting or wheeling shall be allowed on the concrete until it is sufficiently set, and then only on planks laid down for the purpose.

Mixing Concrete. The whole operation of mixing and laying each batch, which shall not contain more than 1 barrel of cement, must be performed as expeditiously as possible by the employment of a sufficient number of skilled men and, if necessary, must be protected from the action of the sun and wind until set. No concrete will be allowed to be used which has been mixed more than 30 minutes.

Bituminous Binder. *Composition.* Upon this concrete foundation must be laid a fine bituminous concrete or binder, to be composed of clean broken stone not exceeding 1¼ inches in their largest dimensions, thoroughly screened, and either coal-tar residuum, commonly known as No. 4 paving composition, or the same bitumen used in the body of the pavement.

Stone to be Heated. The stone must be heated by being passed through revolving heaters and must be thoroughly mixed by machinery, with the paving composition in the proportion of 1 gallon of paving composition to 1 cubic foot of stone.

Laying of Binder. This binder must be hauled to the work and spread with hot iron rakes in all holes or inequalities and depressions below the true grade of the pavements, to such thickness that, after being thoroughly compacted by tamping and hand rolling, the surface shall have a uniform grade and cross section, and the thickness of the binder at any point shall be not less than three-fourths inch. No binder shall be laid during a rain, nor shall any binder be laid that is too cold to be manipulated easily; overheated binder shall be removed entirely from the work.

The upper surface shall be exactly parallel with the surface of the pavement to be laid.

Wearing Surface. Upon this foundation must be laid the wearing surface, or paving proper, the basis of which must be pure asphaltum, unmixed with any of the products of coal tar.

The wearing surface will be composed of:

(1) Refined asphaltum; (2) heavy petroleum oil; (3) fine sand, containing not more than 1 per cent of hydrosilicate of alumina; (4) fine powder of carbonate of lime, granite, or quartz.

Heavy Petroleum Oil. The heavy petroleum oil must be freed from all impurities and brought to a specific gravity of from 18° to 22° Baumé, and a fire test of 250° F., or, if the formula

of the Contractor requires it, the powdered carbonate of lime may be omitted, and the heavy petroleum oil may be replaced by sufficiently fluid natural bitumen.

Asphaltum. The asphaltum used must be equal in quality to that mined from the Pitch Lake on the Island of Trinidad, or from the Alcatraz mine, Santa Barbara County, California, and must be specially refined and brought to a uniform standard of purity and gravity, of a quality to be approved by the Engineer.

Asphaltic Cement. From these two hydrocarbons shall be manufactured an asphaltic cement which shall have a fire test of 250° F., and, at a temperature of 60° F., shall have a specific gravity of 1.19, said cement to be composed of 100 parts of pure asphalt, and from 15 to 20 parts of heavy petroleum oil.

Pavement Mixture. The asphaltic cement being made in the manner above described, the pavement mixture must be formed of the following materials, and in the proportions stated:

Asphaltic cement	From 12 to 15
Sand	From 83 to 70
Pulverized carbonate of lime, granite, or quartz.....	From 5 to 15

Sand. The sand shall be of such size that none of it shall pass a No. 80 screen, and that the whole of it shall pass a No. 10 screen.

Powdered Stone. The powdered carbonate of lime, granite, or quartz shall be of such a degree of fineness that from 5 to 15 per cent by weight of the entire mixture for the pavement shall be an impalpable powder of limestone, and the whole of it shall pass a No. 26 screen.

How Mixed. The sand and asphaltic cement are to be heated separately to about 300° F. The pulverized carbonate of lime, granite, or quartz, while cold, shall be mixed with the hot sand in the required proportions, and then mixed in a suitable apparatus with the asphaltic cement at the required temperature, and in the proportions which will effect a perfect mixture.

Laying of Pavement Mixture. The pavement mixture prepared in the manner thus indicated must be brought to the ground in carts, at a temperature of about 250° F. and, if the temperature of the air is less than 50° F., iron carts, with heating apparatus, shall be used in order to maintain the proper temperature of the mixture; it shall then be carefully spread by means of hot iron rakes in such manner as to give a uniform and regular grade. The surface shall be compressed by hand rollers, after which a small amount of hydraulic cement shall be swept over it, and it shall then be thoroughly compressed by a steam roller

weighing not less than 250 pounds to the inch run, the rolling to be continued for not less than 5 hours for every 1000 square yards of surface. After having received its ultimate compression, the pavement must have a thickness of not less than 2 inches.

Gutters. The gutters for a width of 12 inches next the curb must be coated with hot, pure asphalt, and smoothed with hot smoothing irons in order to saturate the pavement, to a depth to be directed by the Engineer, with an excess of asphalt.

Rock Asphalt. If rock asphalt be used, the material shall be an amorphous limestone, which is naturally, thoroughly, and uniformly impregnated with bitumen: (1) From the Sicilian mines at Ragusa and Verwohle, equal in quality and composition to that mined by the United Limmer and Verwohle Rock Asphalte Company, Limited. (2) From the Swiss mines at Val de Travers, equal in quality and composition to that mined by The Neuchatel Asphalte Company, Limited. Or (3) from the French mines at Seyssel and Mons, and the Sicilian mines at Ragusa, equal in quality and composition to that mined by the Compagnie Génerále des Asphaltes de France, Limited, and it shall be prepared and laid as follows:

Preparation. The rock shall be finely crushed and pulverized; the powder shall then be passed through a fine sieve. Nothing whatever shall be added to or taken from the powder obtained by grinding the bituminous rock. The powder shall contain 9 to 12 per cent natural bitumen; 88 to 91 per cent pure carbonate of lime; and must be free from quartz, sulphates, iron pyrites, or aluminum.

Powder to be Heated. This powder shall be heated in a suitable apparatus to 200°-250° F., and must be brought to the ground at such temperature, in carts made for the purpose; then carefully spread on the binder foundation previously prepared to such depth that, after having received its ultimate compression, it will have a thickness of not less than 2 inches.

Surface to be Rolled. The surface shall be rendered perfectly even by rammers and smoothers, and shall be rolled with a steam roller weighing not less than 250 pounds to the inch run, the rolling to continue for not less than 5 hours for each 1000 square yards of surface in the case of Trinidad asphalt; in the case of rock asphalt pavement the ultimate compression may be by heated pilons.

Special Permission to Lay Rock Asphalt. Rock asphalt shall not be used in any case without written permission from the Commissioner of Highways.

Space Next to Rails, Manholes, etc. On each side of the rails of the car tracks, around all manholes and stopcock boxes, the

Contractor, when required, shall lay a line of granite or syenite paving blocks, as headers; long and short stones alternating and toothing into the pavement, laid on a foundation of 6 inches of concrete, which must extend to the depth of the crossties and beneath and around the girders and stringers; on which shall be laid a bed of fresh cement mortar, 2 inches in thickness; and on the mortar so laid shall be laid the stone blocks, the top surface of which shall conform to the grade of the pavement. The joints of the blocks shall be filled with paving cement, as hereinafter described.

Space within Car Tracks. Whenever the space within car tracks has been laid with granite or syenite blocks, the said space shall be repaved with said blocks or said asphalt, according to the determination of the Engineer.

REFINED ASPHALT

Solid Bitumen Base

Materials and Tests. The refined asphalt to be used for paving mixtures herein required shall be derived in the following manner:

1. By heating crude, natural, solid asphalt, requiring refinement, to a temperature of not over 450° F., until all the water has been driven off. Crude, natural, solid asphalt shall be construed to mean any natural mineral bitumen, either pure or mixed with foreign matter, from which, through natural causes in the process of time, the light oils have been driven off until it has a consistency harder than 100 penetration at 77° F. At least 98½ per cent of the contained bitumen in the refined asphalt, which is soluble in cold carbon disulphide, shall be soluble in cold carbon tetrachloride. In no case shall such asphalt be prepared at the refinery with any product not hereinafter provided for.

2. By the careful distillation of asphaltic petroleum with continuous agitation until the resulting bitumen has a consistency not harder than 30 penetration at 77° F.

(a) All shipments of material shall be marked with a lot number and penetration; and ten samples, taken at random from each lot, shall not vary more than 15 per cent from the average penetration, provided no part of any shipment shall be below 30 penetration at 77° F.

(b) The solid bitumen so obtained shall be soluble in carbon tetrachloride to the extent of 98½ per cent.

(c) When 20 grams of the material are heated for 5 hours at a temperature of 325° F. in a tin box 2½ inches in diameter,

after the manner officially prescribed, the material shall not lose over 5 per cent by weight nor shall the penetration at 77° F. after such heating be less than one-half of the original penetration.

(d) The solid bitumen at a penetration of 50 shall have a ductility of not less than 20 centimeters at 77° F. If the penetration varies from 50, an increase of at least 2 centimeters in ductility will be required for each five points in penetration above 50; and a corresponding allowance will be made below 50 penetration. This test shall be made with a briquette of cross section of one square centimeter, the material being elongated at the rate of 5 centimeters per minute. (Dow molds).

NOTE.—Combinations of asphaltic bitumens having the ductility and other characteristics above mentioned are admitted under Section 2.

3. Refined asphalt produced by combining crude natural asphalt with either of the following:

(a) Residuums obtained by the distillation of petroleum oils as specified under fluxes.

(b) Asphalts obtained by the distillation of petroleum oils as specified.

Use of Bitumen Mixtures. *Fluxes.* In the use of these mixtures of refined asphalts for asphaltic cements, only asphaltic or semi-asphaltic fluxes shall be used, except in those cases where the solid natural asphalt is of such character that when mixed with paraffin flux, without the addition of any other material, it will produce an asphaltic cement complying with the requirements set forth under that head. In such cases any of the fluxes elsewhere specified may be used.

Inspection. The preparation and refining of all asphalt admitted under these specifications shall be subject to such inspection at the paving plants and refineries as the Engineer may direct.

Flux

Material. The fluxing material may be a paraffin, a semi-asphaltic, or an asphaltic residue which shall be tested with and found suitable to the asphalts to be used.

Tests. *Penetration.* The residuums must have a penetration greater than 350, with a No. 2 needle at 77° F. under 50 grams weight for 1 second.

Solubility. All residuums shall be soluble in cold carbon tetrachloride to the extent of 99 per cent, and must remain soft after heating for 5 hours at 400° F.

Miscellaneous. (a) The paraffin residuum shall have a specific gravity of from 0.92 to 0.94 at 77° F. It shall not flash below 350° F. when tested in the New York State Closed Oil Tester, and shall not volatilize more than 5 per cent of material when heated 5 hours at 325° F. in a tin box 2½ inches in diameter, as officially prescribed. The residue after heating shall flow at 77° F. and shall be homogeneous and shall show no coarse crystals.

(b) Semi-asphaltic residuum shall have the same general characteristics as paraffin residuum except that it shall have a specific gravity of 0.94 to 0.98 at 77° F.

Asphaltic Cement

Proportions of Asphalt and Flux. The asphaltic cement prepared from materials above designated shall be made up from the refined asphalt or asphalts, and the flux, where flux must be used, in such proportions as to produce an asphaltic cement of a suitable degree of penetration. The proportion of the refined asphalt, comprising the cement, shall in no case be less than 40 per cent by weight.

When the weight of flux in the asphaltic cement prepared from solid natural asphalt exceeds 25 per cent thereof, asphaltic or semi-asphaltic flux shall be used.

Refined asphalts and flux comprising the asphaltic cement shall, when required, be weighed separately in the presence of the authorized inspectors or agents of the Engineer.

Method of Mixing. Refined asphalts and flux used in preparing the cement shall be melted together in a kettle at a temperature ranging from 250° to not over 375° F.; and shall be thoroughly agitated when heated by air, steam, or mechanical appliances, until the resulting cement has become thoroughly mixed into a homogeneous mass. The agitation must be continued during the entire period of preparing the mixtures. Cement shall always be of uniform consistency and, if any portion should settle in the kettle, between intervals of using the same, it must be thoroughly agitated before being drawn for use.

Tests. (a) The asphaltic cement shall have a penetration of from 40 to 75, which shall be varied within these limits to adapt it to the particular asphalt used in the paving mixture and to the traffic and other conditions. The exact amount of penetration shall be fixed by the Engineer.

(b) When 20 grams of the asphaltic cement of the penetration to be used in the paving mixture shall be heated for 5 hours at a temperature of 325° F., in an oven as officially specified, there must not be volatilized more than 5 per cent of the bitumen pres-

ent, nor shall the penetration at 77° F. after such heating be less than one-half of the original penetration.

(c) A briquette of the asphaltic cement, having a cross section of one square centimeter, when at a penetration of 50, shall elongate to the extent of not less than 20 centimeters at 77° F. If the asphaltic cement as used in the paving mixture varies from 50 penetration, an increase of at least 2 centimeters in ductility will be required for each 5 points in penetration above 50, and a corresponding allowance will be made below 50 penetration. (Dow method.)

Specifications for Sand and Binder Stone

Sand. The sand shall be hard grained and moderately sharp. It shall be so graded as to produce, in the finished surface mixture, the mesh requirements elsewhere herein specified. It shall contain not to exceed 6 per cent of sand that will pass a No. 200 mesh sieve.

Binder Stone. Stone to be used for asphaltic concrete binder shall be hard and durable, free from all foreign substances, and of uniformly varying sizes, from 1 inch down.

Laying the Pavement

Asphaltic Concrete Binder. *Preparation.* Asphaltic concrete binder shall be made as follows: The binder stone and sand as above specified shall be heated to 200°-325° F. in suitable appliances. Stone and sand shall be measured off separately; and then be mixed with sufficient asphaltic cement prepared as heretofore specified, in such proportions that the resulting aggregate will contain by weight material passing a No. 10 mesh screen, between 25 and 35 per cent and bitumen in quantity from 5 to 8 per cent of the entire mixture.

Binder thus prepared shall be a compact mass containing a minimum of voids.

Laying. The asphaltic concrete binder shall be brought to the work in wagons covered with canvas or other suitable material, and upon reaching the street shall have a temperature of 200°-325° F. It shall be placed upon the concrete foundation and raked to a uniform surface to such depth that, after being rolled and thoroughly compacted, it shall have an average thickness of 1 inch and shall be 2 inches below, and parallel to, the surface of the finished pavement. The surface, after compression, shall show at no place an excess of asphaltic cement, and any spot covering an area of 1 square foot or more, showing an excess of asphaltic cement, shall be cut out and replaced with

other material. Smaller spots may be dried by the use of stone dust and smoothers. Any asphaltic concrete binder broken up during the process of laying must be removed and replaced with new material. No more binder shall be laid at any one time than can be covered by a 2 days' run of the paving plant on surface mixture.

Asphaltic Surface Mixture or Wearing Course. *Specifications.* The surface mixture shall consist of asphaltic cement, Portland cement or stone dust, and sand proportioned by weight, so that the resulting mixture will contain average proportions of the whole mixture as follows:

Bitumen soluble in cold carbon disulphide	9.5 to 13.5%
Portland cement or stone dust passing a No. 200 sieve	10.0 to 15.0%
Sand passing a No. 80 sieve	18.0 to 36.0%
Sand passing a No. 40 sieve	20.0 to 50.0%
Sand passing a No. 10 sieve	8.0 to 25.0%
Sand passing a No. 4 sieve	Up to 10.0%

NOTE.—Sieves to be used in the order named.

The item designated as "Portland cement or stone dust passing a No. 200 sieve", within the limits named herein, includes, in addition to the Portland cement or stone dust, fine sand passing a No. 200 sieve not exceeding 4½ per cent of the total mixture, and such 200-mesh mineral dust naturally self-contained in the refined asphalt.

Mixing. Sand and asphaltic cement shall be heated separately to about 300° F.; the maximum temperature of the sand at the mixers shall in no case be in excess of 375° F. and the maximum temperature of the asphaltic cement shall not exceed 325° F. at the discharge pipe. The Portland cement or stone dust shall be mixed with the hot sand and in the required proportions; and then these shall be mixed for at least 1 minute, with the asphaltic cement at the required temperature and in the proper proportions, in a suitable apparatus so as to effect a thoroughly homogeneous mixture.

The proportion of asphalt cement shall at all times be determined by actual weighing with scales attached to the asphaltic cement bucket. The weight of the bucket shall be checked up at least twice every day.

The Portland cement or stone dust and sand must also be weighed unless a method of gaging approved by the Engineer shall be used.

For the determination of the temperatures required by the specifications throughout the process of manufacture, the contractor shall provide and maintain at the plants suitable registering thermometric instruments to be approved by the Engineer. Proper weighing devices must also be installed and maintained for the determination of the quantities of materials used.

The Contractor shall furnish every facility for the verification of all scales or measures.

The sand gradings and bitumen may be varied within the limits designated at the discretion of the Engineer.

Laying the Wearing Surface. The asphalt wearing surface shall be hauled to the work in wagons provided with a canvas or other suitable cover. As placed in the street it shall have a minimum temperature of 250°-280° F. as suitable for the asphalt used. It shall be dumped at such distance from the work that all of the mixture can be turned and distributed to the place where it is to be raked; and shall be spread, while hot, to such depth upon the asphaltic concrete binder—which must be thoroughly dry, free from leaves, or other foreign matter—that after receiving its ultimate compression by rolling, it shall have an average thickness of two inches. The initial compression shall be effected by means of a small roller, after which a small amount of Portland cement or mineral dust shall be swept over the surface. Final compression shall be effected by a roller of not less than 200 pounds per inch tread. The rolling shall be carried on continuously at the rate of not more than 200 square yards per hour.

All tests herein provided must be conducted according to official methods on file in the office of the Chief Engineer. All penetrations indicated herein, unless otherwise specified, refer to the depth of penetration in hundredths of a centimeter of a No. 2 cambric needle weighted to 100 grams at 77° F. acting for 5 seconds.

No asphalt shall be laid when, in the opinion of the Engineer, the weather conditions are unsuitable for its proper laying; and no asphalt shall be laid unless the surface on which it is to be laid is dry.

After the surface shall have been finished, no horse or vehicle traffic of any kind shall be permitted on the pavement until it shall have hardened sufficiently.

Should an asphalt pavement have to be laid adjacent to the tracks of a street railroad, granite paving blocks will be laid next to the track, for which the Contractor will be paid the price named in the proposal for new granite block paving upon cement concrete foundation.

The granite blocks shall be laid upon a cement concrete foundation, mixed in accordance with these specifications, which shall extend to the depth of the bottom of the crossties.

The top of the blocks shall be even with the surface of the tread of the rail, which must conform with the grade of the street. The blocks shall be laid before the wearing surface is laid upon the driveway, thoroughly backed with cement concrete, carefully rammed to a firm bed. All joints must be thoroughly filled with cement grouting composed of one part fresh ground Portland cement and one part clean approved sand.

Asphalt-filled manhole covers and frames, when ordered by the Engineer, shall be placed on all manholes where such frames and covers have not already been placed. Payment for all such frames and covers will be made at the prices named in the proposal.

WOOD-BLOCK PAVEMENT

Material Specifications. The wood-block pavement layer shall be.....inches thick, as required by the traffic and conditions of the street; and constructed of the materials and in the manner hereinafter specified.

Long-Leaf Yellow Pine. The wood from which the blocks are made must be regular, sound, commercial, merchantable, long-leaf yellow pine, which shall be well manufactured, saw-butted, free from large coarse knots or very coarse grain, and free from the following defects: unsound, loose, and hollow knots, worm holes, knot holes; through, round, or other objectionable shakes; wane, checks, bark; incipient or other decay.

Other Woods. Other woods, as Oregon or Washington Douglas fir, scientifically and practically equal or superior to the above mentioned long-leaf pine, which can be equally well creosoted and which are satisfactory to the City Engineer, can be used, provided that only one kind and quality of wood is used on the same street or contract and further provided that only one kind of wood is treated and creosoted at one time.

Wood Blocks. The paving blocks, cut from the lumber or wood above specified, shall be well manufactured, truly rectangular, and uniform. They shall be dressed on all sides; except the top and bottom, both of which shall be evenly and smoothly sawed. No block shall vary in width and depth more than one-sixteenth of an inch from others used on the same street or contract. The depth shall be.....inches as already specified. The length shall be not less than 6 nor more than 10 inches. The width shall be not less than 3 nor more than 4 inches, provided that all blocks used in one street or contract shall be of the same width.

Creosote Oil. *Amount per Cubic Foot.* The blocks shall be treated, preserved, or creosoted as hereinafter specified and each block shall contain at least 18 pounds of creosote oil per cubic foot of wood; or when a block contains much natural pitch it shall receive as much creosote as can be forced into it by the same process and pressure as is used in the treatment of blocks of the same kind of wood which will receive 18 pounds of creosote oil per cubic foot; provided, however, that the combined creosote and natural pitch in all blocks be at least 19 pounds per cubic foot.

Quality Tests. The creosote oil shall be a dead oil of coal tar or a coal-tar product. It shall not contain more than 3 per cent of water; and if it does contain this amount of water, a corresponding correction must be made so that an equivalent additional amount of creosote is forced into the blocks. It shall contain only traces of acetic acid and acetates. Its specific gravity at 100° F. (38° C.) shall be at least 1.03 and not more than 1.10, so as to assure its thoroughly penetrating the wood blocks. It must not leave more than a trace on a filter paper when filtered between 60° F. and 77° F. Fractional distillation of 100 grams of the creosote oil shall produce percentages of dry oil by weight within the following limits:

Up to 150° C. (302° F.) no distillate
Between 150° C. (302° F.) and 170° C. (338° F.) not to exceed 1.5 per cent
Between 170° C. (338° F.) and 235° C. (445° F.) not to exceed 33.0 per cent
Between 235° C. (455° F.) and 300° C. (572° F.) not to exceed 35.0 per cent

The residue shall be soft and adhesive. The creosote oil shall contain about 25 per cent of crystallizable naphthalene and at least 15 per cent anthracene oils. At least 95 per cent of the creosote oil shall be equally soluble in carbon bisulphide and in absolute alcohol.

Treating the Blocks. *Sterilizing.* The wood blocks, after being cut and ready for treatment, shall be placed in a suitable iron receptacle or cylinder and there sterilized with dry steam under a pressure of at least 30 pounds, and not to exceed 50 pounds per square inch during at least 3 hours and as much longer, not to exceed 7 hours, as the condition of the wood and the season of the year requires. The temperature within the cylinder during the process of steaming shall be between 250° F. and 280° F. At intervals during this process the condensed steam, sap, and other liquid matter shall be drawn from the receptacle by means of valves. At the completion of the steaming process, all condensed steam and other fluid matter shall be blown from the cylinder

through an opening in its bottom, and the steam shall be caused to pass out through an opening in its top.

Vacuum Treatment. The draining and exhaust valves of the cylinder shall then be closed and a vacuum pump shall immediately produce, as quickly as possible, a vacuum of at least 24 inches, and as much more as may be necessary; this vacuum shall be maintained in the cylinder until moisture and gases cease to come from the cylinder. During this process the wood blocks within the cylinder shall be kept hot by means of steam coils within it.

Forcing Creosote Oil into the Blocks. Immediately after the vacuum treatment and while the vacuum exists, the creosote oil at a temperature between 180° F. and 200° F. shall be run into the cylinder and forced and maintained under such pressure that the wood blocks shall absorb and be impregnated with creosote oil to the amount as required above. The excess of creosote oil in the cylinder shall then be withdrawn; the blocks drained and prepared for shipment.

Water Absorption. The blocks when ready for use shall not absorb more water than an average of 4½ per cent of their dry weight, after being heated at 100° F. during 12 hours and then placed under water 12 hours.

Indentation Pressure Test. The blocks ready for use must meet the indentation pressure test made as follows: The blocks to be tested are first dried at 100° F. during 12 hours. Then a polished steel die of 1 square inch on its lower face, with square edges and corners, and perpendicular sides, is placed on a dried block, firmly supported in a compression testing machine. A pressure of 8000 pounds is applied quickly and maintained exactly 1 minute. The die must not descend and indent the block more than one-eighth of an inch. The measurements are to be taken from the time when the die is lightly pressed against the block to the instant the 8000-pound pressure has been applied 1 minute. The die is placed anywhere within one-half inch of the edges of the block and so as to compress lengthwise the wood fibers.

Inspection of Blocks. The wood blocks shall be inspected by the City Engineer at the place of manufacture, or on arrival in the city where they are to be used, or when piled adjacent to the street to be paved. All blocks not in conformity with the requirements of these specifications will be rejected and must be removed from the locality of the pavement to be laid.

Laying Blocks. The wood blocks are to be laid upon the mortar bed immediately after the said bed is ready to receive them. Except when otherwise directed by the City Engineer, the blocks are to be laid with close joints and at right angles

to the curbs; in uniform courses; and so that all longitudinal joints shall be covered by a lap of at least 3 inches. No closure or end blocks less than 3 inches long shall be used.

Tight Joints and Rolling. The blocks shall be driven or forced together as closely as possible during laying, and shall be properly rolled or rammed to a firm bearing and uniform surface.

Defective Blocks. No rolling or ramming shall be done within 10 feet of the surface where blocks are being laid. All blocks which are broken, split, or otherwise damaged, defective, or displaced shall be removed immediately after rolling or ramming and replaced with sound blocks.

Filling Joints. After the blocks have been laid and properly rammed, their joints shall be filled or grouted with either a suitable bituminous paving joint cement approved by the Engineer, or by a cement grout. The bituminous cement must be such as not to be too soft in warm weather, and not too brittle in cold weather to be a durable and adhesive filler. It must be heated until it is so liquid that it will run freely into and fill the joints. The cement grout shall be composed of two parts of clean sand and one part of an approved brand of Portland cement, mixed to a perfectly liquid form; and the surface of the block shall be slushed with the same, and the joints shall be swept until they are completely filled.

Surface Sand. Immediately after the grout or bituminous cement has filled the joints, there shall be spread over the entire pavement a one-half-inch layer of clean, very coarse, dry sand; or a layer of clean, hard, dry, crushed stone screenings with particles not exceeding one-fourth inch and not smaller than one-thirty-second of an inch in size. This layer of either coarse sand or crushed stone screenings is to remain on the pavement while it is subjected to traffic for a period of at least a month, or until any excess is removed as far as possible or necessary by the City.

Expansion Joints. Expansion joints shall be constructed between the curbs and wood paving blocks to provide for the possible expansion and contraction of the blocks by heat or cold or other conditions. These expansion joints shall be constructed from three-fourths inch to 1 inch wide, according to the width of the street, as directed by the Engineer; and shall extend the whole depth of the blocks; and shall be filled with a suitable bituminous paving joint cement acceptable to the Engineer. Expansion joints of any required width shall be constructed at such other locations as the Engineer may direct. Expansion joints must be completely filled with suitable strips of wood previous to filling the joints with the paving joint cement.

Any bituminous cement adhering to curbs or sidewalks must

be removed by the contractor. The pavement and sidewalk shall be free from all surplus materials as soon as the Contractor has finished paving the street.

GRANOLITHIC SIDEWALK PAVEMENTS

Bed. The sidewalk shall be excavated and graded from the curb to the house line, or to the width required, to a subgrade 18½ inches below and parallel to the top of the finished pavement. The bed shall be thoroughly compacted by ramming to the prescribed lines.

Cinder Foundation. On the subgrade so prepared a foundation of clean, hard coal cinders, not less than 14 inches thick, shall be placed in two 7-inch layers, which shall be well consolidated by ramming with a rammer weighing at least 75 pounds, and having a face at least 8 inches square.

The cinders shall be well watered during ramming, and the top surfaces shall be brought to a height exactly 4½ inches below and parallel to the finished surface.

Concrete Base. On this cinder foundation shall be placed 3 inches of Portland cement concrete. This base shall be cut by joints into blocks not larger than 6 feet square, the joints to extend clear through the concrete.

Wearing Course. On this concrete base, and before the concrete has attained its initial set, shall be placed the finished or wearing course. This course shall consist of a stiff mortar composed of equal parts of Portland cement and the sharp screenings of crushed granite or stone of equal quality, to be approved by the Engineer, the largest particles of which shall pass through a three-eighths-inch ring; and it shall be free from dust, loam, or earthy substances; and shall be laid to a full depth of 1½ inches, carefully floated and troweled to a smooth, even surface. A drier mixed in the proportion of 1 part sand to 2 parts Portland cement shall be sprinkled in a dry state over the surface, and then floated and troweled. This treatment shall be repeated 3 times; after which the joints shall be cut through the wearing surface directly over the joints in the concrete base, troweled with a small jointer, and the entire surface indented in a manner to be approved by the Engineer.

Tinting. When directed, the drier mixture shall receive the blue, black, or other tinting matter to produce the shade approved by the Engineer.

Sprinkling. When the pavement is completed, it shall be kept covered for 3 days, during which time it shall be kept moist by sprinkling.

BRICK PAVEMENT

For brick sidewalk paving the sidewalk shall be excavated or filled and graded from curb to house line or to the width required; and firmly and uniformly compacted, by ramming or rolling, to a subgrade of not less than 6 inches below the intended finished grade of pavement, and parallel to it. All soft and spongy places shall be dug out and properly refilled. Upon the bottom so formed shall be placed a layer of sharp clean bar sand, upon which the paving brick shall be laid. The bricks shall be straight, hard, first quality paving bricks laid in the best workmanlike manner. Samples of bricks must be submitted for approval at least 10 days before they are desired for use.

SODDING

Quality of Sod. The Contractor shall furnish and place grass sod on the slope of the embankment and at other places as directed by the Chief Engineer. The sod shall be of good quality of earth covered with heavy grass; sound and healthy; free from weeds; at least 1 foot square and 2 inches thick; cut with a bevel on the sides so that when laid they will lap at the edges. No poor, lean, or broken sod will be allowed in the work.

Laying. The sod shall be carefully set so as to have a full bearing on their lower surfaces, and shall be properly rammed and well rolled, and wherever required by the Chief Engineer they shall be pinned down with wooden pins not less than 12 inches long. The surface of the top soil shall be dampened immediately before laying the sod. Care shall be taken to have all surfaces conform to the proper lines and grades, and any sliding or settling which may occur, before the final acceptance of the work, shall be repaired by the Contractor.

Grass sodding, in place, shall be paid for at the price given in the proposal.

GENERAL SPECIFICATIONS FOR THE DESIGN OF ELEVATED TANKS AND STANDPIPES

LOADS

Definitions. (1) The dead load shall consist of the weight of structural and ornamental steelwork, platforms, roof construction, piping, etc.

(2) The live load considered shall be the contents of tanks, the movable load on platforms and roofs, and the wind pressure.

(3) The weight of water shall be assumed to be 63 pounds

per cubic foot; and that of crude oil 56 pounds per cubic foot, 1 cubic foot of fluid being equal to 7.48 gallons.

(4) The live loads on platforms and roofs shall be taken at 30 pounds per square foot or a 200-pound concentrated load applied at any point.

(5) The wind pressure shall be assumed at 30 pounds per square foot, acting in any direction. The surfaces of cylindrical tanks exposed to the wind shall be calculated at two-thirds of the diameter multiplied by the height.

(6) The movable live load on platforms and roofs shall not be considered as acting together with the wind pressure.

UNIT STRAINS

Sums of Dead and Live Loads. All parts of the structure shall be proportioned so that the sum of the dead and live loads shall not cause the strains to exceed those given in Table I.

TABLE I

Maximum Tension, Compression, and Shearing Stresses for Tanks and Standpipes

Strains in Various Members	Pounds per Square Inch
Tension in tank plates (net area)	12,000
Tension in other parts of structure (net area)	16,000
Compression (reduced)	16,000
Shear on rivets and pins	12,000
Shear on bolts and field rivets	9,000
Shear in plates (gross section)	10,000
Bearing pressure on rivets and pins	20,000
Bearing pressure on field rivets	18,000
Fiber strain in pins	24,000

Compression Factor. For compression members, the permissible unit strain of 16,000 pounds shall be reduced by the formula

$$p = 16{,}000 - 70\frac{l}{r}$$

where p = permissible working strain in compression, in pounds per square inch

l = length of member, from center to center of connections, in inches

r = least radius of gyration of section in inches

The ratio $\frac{l}{r}$ shall never exceed 120 for main members and 150 for struts.

Wind Stresses. Stresses due to wind may be neglected if they are less than 25 per cent of the combined dead and live loads.

Unit strains in bracing and other members taking the wind stresses may be increased to 20,000 pounds per square inch, except as shown above.

The pressures given in Table II will be permissible on foundation and bearing plates.

TABLE II

Maximum Allowable Pressures on Foundation and Bearing Plates

Foundation Material	Tons per Sq. Ft.
Soft clay	1
Ordinary clay	2
Dry sand and dry clay	3
Hard clay	4
Gravel and coarse sand	6
Bearing Plates	**Lbs. per Sq. In.**
Brickwork with cement mortar	200
Portland cement concrete	350
First-class sandstone	400
First-class limestone	500
First-class granite	600

DETAILS OF CONSTRUCTION

Calking. The plates forming the sides of cylindrical tanks shall be of different diameters, and shall be calked from the inside. No foreign material shall be allowed when calking.

In oil-tank work, both the inside and the outside of the tank shall be beveled for calking.

Joints. Joints for horizontal seams and for radial seams in the spherical bottoms of tanks shall preferably be lap joints.

For vertical seams lap joints shall be used for one-fourth-, five-sixteenths-, and three-eighths-inch plates; for all other thicknesses, butt joints with double and triple rows of rivets on both sides of joint shall be used.

Rivets. Rivets five-eighths inch in diameter shall be used for one-fourth- and five-sixteenths-inch plates; rivets three-fourths inch

in diameter for three-eighths- to five-eighths-inch plates, inclusive; and rivets seven-eighths inch in diameter for eleven-sixteenths- to 1-inch plates, inclusive.

Plates. Plates more than five-eighths inch thick shall be sub-punched and reamed.

The minimum thickness of the plates for the cylindrical part shall be one-fourth inch. The thickness of the plates in spherical bottoms shall never be less than that of the lower ring in the cylindrical part of the tank.

The facilities at the plant where the material is to be fabricated will be investigated before the material is ordered.

All plates shall be punched before being bevel sheared for calking.

Spherical Bottoms. Radial sections of spherical bottoms shall be made in duplicates of the number of columns supporting the tank, and shall be reinforced at the lower parts, where holes are made for piping.

When the center of the spherical bottom is above the point of connection with the cylindrical part of the tank, there shall be provided a girder at said point of connection to take the horizontal thrust. The horizontal girder may be made in connection with the balcony. This also applies where the tank is supported by inclined columns.

The balcony around the tanks shall be 3 feet wide with a one-fourth-inch floor plate, and shall have a suitable railing 3 feet 6 inches high.

The upper parts of spherical bottom plates shall always be connected on the inside of the cylindrical section of the tank.

Connections between Tower Columns and Tank. In order to avoid eccentric loading on the tower columns and local stresses in spherical bottoms, the connections between the columns and the sides of the tank shall be made in such a manner that the center of gravity of the column section intersects the center of connection between the spherical bottom and the sides of the tank. Enough rivets shall be provided above this intersection to transmit the total column load.

If the tanks are supported on columns, riveted directly to the sides, additional material must be provided in the tank plates riveted directly to the columns to take the shear. The shear may be taken by providing thicker tank plates or by reinforcement plates at the column connections. Connections to columns shall be made in such a manner that the efficiency of the tank plates is not less than that of the vertical seams.

High Towers. For high towers, columns shall have a batter of 1 to 12. The height of the tower is understood to be the dis-

tance from the top of the masonry to the connection of the spherical bottom, or the flat bottom, with the cylindrical part of the tank.

Standpipes. The bottom plates of standpipes shall be not less than five-sixteenths inch thick, and shall be provided with tapped holes, 1¼ inches in diameter, with screw plugs spaced at 4-foot centers to allow a filling of cement on top of the masonry, while the bottom is being erected, in order to secure the proper bearing.

Near the bottom of the standpipe there shall be provided one 12- by 18-inch manhole of elliptical shape.

Near the top of each tank and standpipe there shall be provided one **Z**-bar acting as a support for the painters' trolley and for the stiffening of the tank. The section modulus of the same shall be not less than $\frac{D^2}{250}$ where D is equal to the diameter of the tank, in feet. If the upper part of the tank is held by the roof construction, this may be reduced.

Stiffening Angles on Large Tanks. On large tanks, circular stiffening angles shall be provided in order to prevent the tank plates from buckling during windstorms. The distance between the angles shall be located by the following formula:

$$d=\sqrt{t\frac{900}{D}}$$

where d = approximate distance between angles, in feet
t = thickness of tank plates, in inches
D = diameter of tank, in feet

Roof Plates. The top of the tank will generally be covered with a conical roof of thin plates, and the pitch shall be 1 to 6. For tanks up to 22 feet in diameter, the roof plates will be assumed to be self-supporting. If the diameter of the tank exceeds 22 feet, angle rafters shall be used to support the roof plates.

Plates of the following thicknesses will be assumed as self-supporting for various diameters: three-thirty-seconds-inch plate, up to a diameter of 18 feet; one-eighth-inch plate, up to a diameter of 20 feet; three-sixteenths-inch plate, up to a diameter of 22 feet.

Rivets in the roof plates shall be from one-fourth to five-sixteenths inch in diameter and shall be driven cold. These rivets need not be headed with a button set.

A trapdoor, 2 feet square, shall be provided in the roof plate.

Near the top of the higher tanks a platform with a railing shall be provided, for the safety of the men operating the trap-door.

An ornamental finial shall be provided at the top of the roof.

Ladder. A ladder 1 foot 3 inches wide shall be provided from a point about 8 feet above the foundation to the top of the tank, and also one shall be provided on the inside of the tank. Each ladder shall be made of two $2\frac{1}{2}$- by $\frac{3}{8}$-inch bars with three-fourths-inch rungs. On large high tanks, 30 feet or more in diameter, a walk shall be provided from the column nearest the ladder to the expansion joint on the inlet pipe.

Overrun. In designing tanks, 6 inches additional height shall be allowed for overrun.

Bracing. The bracing in the towers shall not be adjustable.

Anchor Bolts. The size of the anchor bolts shall be determined by the uplift when the tank or standpipe is empty. The unit strains in the anchor bolts shall not exceed 15,000 pounds per square inch, and the minimum section shall be limited to a diameter of $1\frac{1}{4}$ inches.

Miscellaneous. The concrete shall be assumed to have a weight of 140 pounds per cubic foot and shall be sufficient in quantity to take the uplift.

Any parts of the tank, standpipe, or tower, in which difficulties may arise in field riveting, shall be assembled in the shop, and marked properly before shipment.

The structural material shall conform to the "General Specifications for Steel Railroad Bridges" as adopted by the American Railway Engineering and Maintenance of Way Association.

The workmanship shall be in accordance with the Manufacturers' Standard Specifications of Feb. 6, 1903.

Before leaving the shop all work shall be painted with one coat of approved paint, excepting the laps in contact on the tank work. All parts which will be inaccessible after erection shall be well painted. After erection, the structure shall be covered with one coat of the same paint.

Three-ply frost-proof casing shall be provided, if necessary, around the inlet pipe. This casing shall be composed of two layers of 1- by $2\frac{1}{2}$-inch lumber, and each layer shall be covered with tar paper, and one outside layer of $\frac{7}{8}$- by $2\frac{1}{2}$-inch dressed and matched flooring. The lumber shall be in lengths of about 12 feet. A 1-inch air space shall be provided between the layers of lumber, and wood rings or separators shall be nailed to them every 3 feet. The frost casing may be made square or cylindrical.

CONTRACT, OR ARTICLES OF AGREEMENT

Nature and Purpose. A contract is an agreement between two or more parties to do a certain thing, such as delivering material, performing work, etc., and is based upon a mutual understanding between the parties to the agreement as to the nature of the work to be done, the kind of materials to be supplied, etc., and the amount of the consideration to be paid.

Everything that will prevent misunderstanding as to the intention of the parties to the contract should be embodied in and form a part of the contract. Hence, as already stated, the advertisement, the proposal, the drawings, the specifications, and the written articles of agreement should all form essential parts of the contract. There should be as many copies of the contract executed as there are parties to it, each party retaining a copy.

Number of Parties to a Contract. It is claimed by some authorities that there can be but two parties to a contract. However, we have many examples of agreements between corporations, where there are as many parties to the contracts as there are interests. There are also contracts between financiers, promoters, engineers, and contractors often involving many parties.

ESSENTIAL ELEMENTS

The four essential elements of all contracts, without which no contract is valid, are as follows:

(1) Appropriate parties; or parties with capacity to contract.
(2) Mutual consent to the terms of the agreement—a mutual understanding.
(3) A definite subject—matter to be acted on.
(4) A valid or lawful consideration, actual or presumed—a something in exchange for its legal equivalent.

The Parties. To every contract there must be at least *two parties,* but there may be more than two. The parties may be either individuals, firms, or corporations and are designated in the agreement as the party of the first part and the party of the

second part; when there are other parties, which is unusual, they are designated as the party of the third part and the party of the fourth part. The party who has something to be done, or who is to pay the money, is generally designated as the party of the first part. The person or corporation who proposes to do the work for a consideration, or to sell something, is generally designated as the party of the second part, although there is no fixed rule in this matter.

Appropriate Parties. Any person, firm, or corporation *may* be a *competent* party. There are exceptions to every rule. Generally corporations may contract only within the scope of their charter and by-laws by which they are usually limited.

Generally speaking, any person of sound mind and legal age may make a contract. There are, however, exceptions differing in different localities. As an instance, married women are limited in their right to make contracts in certain States. But as their powers are being extended, a local attorney at law should be consulted in making contracts with them.

A contract with a person of unsound mind is not binding upon the weaker person.

Unsoundness of mind may be either temporary — as, from intoxication—or constitutional. When, therefore, there is the slightest evidence of mental unfitness, no contract should be made, as litigation is thereby courted. It is needless to say that a contract should never be executed under threat.

Corporations. In a contract, a corporation is considered as a single individual, regardless of the number of its members. It is of the greatest importance that it be known which officers of a company are authorized by its charter or by-laws to execute contracts. The president and the vice-president of a corporation are generally authorized to execute contracts for their company. The execution is usually witnessed by the officers' signatures and the seal of the company, attested by the secretary, the signatures generally being acknowledged before a notary public or a commissioner of deeds. Important contracts shall also have the approval of the board of directors of the company. It is important that the limitation of the powers of the company's charter be known before the contract is drawn.

Full Description of Parties. The parties to a contract must be so fully described that there can be no mistake made as to their identity. A firm's full name and place of business, together with the names of the individuals comprising it, should be given. An individual should be identified by his residence and occupation and a corporation by its full title, and the name of the State or Country wherein it was incorporated.

Signatures to Agreement. It is necessary that the names of the parties used in the body of the agreement be exactly in accord with the signatures at the end thereof; discrepancies in the names might invalidate the contract.

United States Government a Party. The United States Government cannot be sued for noncompliance with a contract, although it may bring suit against the other party to the contract—so a State may not be sued by an individual. A public official cannot be held personally liable for obligations made by him in his official capacity.

Mutual Consent. A contract is not legal unless both parties thereto have agreed to the same thing.

Hence an offer must be accepted before it becomes binding and until accepted may be withdrawn. It has been said that an offer by letter should be accepted by return mail; an offer by telegram, by return telegram, etc. All offers should be in writing to eliminate controversies; therefore they should be accepted or rejected promptly.

If the party accepting impose any new conditions, they, in turn, must be agreed to by the other party, before a contract can be entered into.

Subject Matter. The subject matter of a contract may be anything that is not immoral or illegal, and it must concern some act to be carried out. The subject matter must be described so fully and clearly that both parties will understand all conditions of the agreement, as a contract that is obscure or ambiguous leads to controversy and perhaps litigation. In case of dispute as to the meaning of the subject matter, custom and usage have great weight in the courts.

Consideration. The consideration, or the price or reason of the promise, should be clearly and fully set forth in the agree-

ment. The consideration makes the contract legal and must be real and substantial.

ANALYSIS OF CONDITIONS

Provide for all Conditions. It is of great importance that all probable and possible events in connection with the contract be foreseen and provided for in drawing the agreement. It requires great experience and ability to be able to foresee and provide for all conditions that may arise in the course of the work. It is, therefore, best for the Engineer to follow the standard form of some acknowledged authority until he becomes experienced in contract drawing, making such changes as are necessary to suit his conditions.

Duties of Parties. Each contract must stand on its own basis; that is to say, where the work to be done is legal; methods of doing it legal; the parties making it competent to act; and the agreement set forth in writing. The agreement so made becomes law between the parties. In case of disputes the courts can only construe contracts, so as to determine what the intentions of the parties were; hence the necessity of the contract specifically setting forth the duties and obligations of the respective parties thereto. It must be remembered that though the Engineer draws the contract, the courts may be called upon to construe it.

Guaranty. A guaranty in the form of a bond or certified check is generally required of bidders on public works. This is to reimburse the owner for the cost of re-advertisement and delay in case the successful bidder fails to execute the contract, and to compensate for loss or damages incident to delay in completion of the work, caused by the failure of the bidder.

Bond. A surety bond, to enter into contract, should be required of the Contractor on all contracts for public works, and on all other important contracts (the amount of such bond being set forth in the notice to bidders), for the faithful performance of the contract and prompt payment for labor and material, and as a protection to the Company against all damage to persons or property caused by negligence of the Contractor or his employes.

In some contracts for public works, one bond is required to

cover the performance of the contract; another one to protect the material, men, and labor; and still others, covering other requirements due to local laws. There is no rule for the amount of the bond to be given by the Contractor. Bonds must generally be sued upon in order to recover, throwing the burden of proof upon the Company.

Payment Clauses. In the payment clauses in the contract, under various conditions, the Engineer is authorized to withhold payment until the objectionable conditions are removed by the Contractor. It is, therefore, sometimes considered that a "withheld payment" is one of the best means of securing the desired end—the old story of "touching a man's pocketbook" to gain results. The withheld payment throws the burden of proof on the Contractor, in case of dispute; is simple and direct, and, therefore, easy of application. It has been said with truth that "the guaranty of good work is intelligent and faithful inspection, withheld payments, and the Contractor's bond."

Arbitrators. The employment of the *arbitration clause* is not to be recommended, as in case of controversies it is rare that the parties to the contract will abide by the conditions of the arbitration clause, generally preferring to throw the dispute into the courts, rather than trust their interests to the unknown qualifications of arbitrators.

They may decline even to appoint arbitrators. If, however, each party appoints an arbitrator to act in the matters of controversy and executes an instrument agreeing to abide by the decision of the arbitrators chosen, according to the terms of the contract, they are irrevocably bound by the findings of the board. The following clause has been used by the writer in a few cases:

Arbitration. In the case of any difference or dispute arising between the Company and the Contractor, during the execution of the work, other than the meaning of the specifications and drawings, which shall be interpreted by the Engineer, the same shall be referred to 3 disinterested arbitrators, one to be appointed by each of the parties to this contract and the third by the two thus chosen, the decision of any 2 of whom shall be final and binding on the parties thereto; and cost and expenses of said arbitration, including reasonable witness fees, shall be imposed upon either of the parties hereto, or divided between said parties in an equi-

table manner by the arbitrators, and shall be paid by said party or parties in accordance with the arbitrators' decisions.

Manufactured Products. In contracts involving the supply of manufactured materials such as structural steel or building materials, when the party supplying same is subject to strikes, floods, etc., a clause such as the following is often inserted in the contract to limit the liability of the Contractor, and is considered equitable.

Strikes, Floods, etc. The times herein mentioned for completion of the work are subject to delays due to transportation, strikes, fires, floods, storms, or other causes beyond the Contractor's control. Should the work be delayed by any of the foregoing causes, the Contractor shall have additional time, not less than the extent and sum of said delays, in which to complete his work under this contract. This extension of time shall be commensurate with the specified excusing cause or causes.

NOTE.—Local Laws. The local lien and labor laws should be most carefully looked into before the drawing of a contract. They are different in different States. Some prescribe the hours of labor and amount of pay for workmen; others provide that the person furnishing the materials of construction and the laborers shall have a preferred claim to that of the Contractor; still others require that the contract be filed with some official, to prevent serious and expensive legal disputes among the owner, contractor, material men, sub-contractors, laborers, etc. Too much importance cannot be given to the drawing and filing of contracts where the local lien and labor laws are in force. Local customs and usages, in the matter of measuring plaster, brick work, masonry of different kinds, etc., must be provided against in the contract.

FORMS OF AGREEMENT

In preparing a form of agreement, it is well to have a list of the various essentials to a well-drawn civil engineering contract before the writer, in order to avoid the omission of important clauses. The following provisions should be included in the agreement:

Opening Clause. A correct form for the opening clause. There are many forms that are correct and it is not material which is used. To make the form more readily understood, names and dates in the examples given below have been filled in.

THIS AGREEMENT, Made and Entered Into this tenth day of July, in the year of our Lord 1914; by and between Green Mountain Railroad Company, a corporation created by and existing under the laws of the State of New Jersey, and having its principal office at 509 South Broad Street, in the City of Newark,

in said State, hereinafter called "Company", party of the first part; and Smith, Jones, and Company, of the City of Chicago, State of Illinois, a firm composed of John G. Smith, James S. Jones, and William F. Brown, having its principal place of business at 14 South Front Street, in the City of Chicago, and State of Illinois,

party of the second part, hereinafter called the "Contractor", Witnesseth:—

or

ARTICLES OF AGREEMENT, Made and Concluded this tenth day of July, A. D. 1914, by and between Brooklyn Terminal Company, a corporation created by and existing under the laws of the State of New York, and having its principal office at 18 South Water Street, in the Borough of Brooklyn, City of New York, in the said State, hereinafter called "Company",

party of the first part; and James Dolan, Contractor, residing at 710 Burns Avenue, in the City of Boston, State of Massachusetts,

party of the second part, hereinafter called the "Contractor", Witnesseth:—

Parties. It is advisable to designate the parties to the contract for the sake of brevity by one word as: *Company, Engineer, Contractor, Agent, Trustee, Owner, Purchaser, Incorporator, Board, City,* etc., as the case may be.

Arrangement of Clauses. Following the opening clauses should come the specific *covenants* and *agreements* of the respective parties to the contract, which should be set forth as clearly and unequivocally as possible.

Plans and Specifications. Where the plans and specifications

are properly drawn they should, of course, show the quantity and quality, and, as far as possible, the amount of work to be done, material to be furnished, and the time and method of making payments; also the time of beginning and of completing the work, and other details of the operation; hence the articles of agreement must specifically state that the work and labor to be done, and materials to be furnished and delivered, must be in strict and exact accordance with the proposal, plans, and specifications attached to the Articles of Agreement which are made a part of the contract.

Materials, Workmanship, and Damages. Usually the Articles of Agreement should also state that the materials and workmanship are to be the best of their kinds, and should provide for the proper inspection thereof; for their approval or rejection; for the replacing of defective material or workmanship; for a time within which the work should be performed; and for a specific stipulation that upon failure of the Contractor to complete the work within the time specified, a fixed sum shall be deducted from the contract price for each and every day that the work remains incomplete, as *ascertained* and *liquidated damages* and *not* as *a penalty.*

In fixing the amount of liquidated damages for each day's delay, due consideration should be given to the actual loss to the Company for such delay, as courts are inclined to look with disfavor upon anything in the nature of a penalty.

Prosecution of Work. The Articles of Agreement should also contain a covenant for due prosecution of the work, and should provide means and methods by which the Company may proceed to furnish the materials or complete the work upon the failure or neglect of the Contractor to comply with the terms of the contract.

Surety. It should also provide for the entry of security for the proper performance of the contract by bond or otherwise. Personal bonds should be avoided whenever possible, and good surety company security accepted instead. The bond is a very important factor in the contract and the clause should be very carefully drawn and in such a manner (if it is possible) that the necessary changes in plans and specifications may be made without vitiating the bond. It is of the greatest importance that before any changes or alterations are made, the person or surety company

on the Contractor's bond be notified of the Engineer's intention, and their consent obtained before proceeding with the work.

Protective Clause. It should further provide for proper protection of the work and precautions against accidents and an assumption of liability by the Contractor of all damages to persons or property resulting from the prosecution of the work. Provision should be made against assigning, transferring, or subletting the contract; and should specify that it is subject to all local laws regulating the employment of workmen and the protection of material men and sub-contractors; and for the protection of the Company the contract should contain an appropriate clause drawn in accord with the local laws waiving the right of the Contractor, material men, laborers, or sub-contractors to file liens. This last covenant should be drawn by a local attorney; in most instances the contract should be filed in accordance with the law of the place where the work is to be done.

Contract Price. The Agreement should also contain the amount to be paid and method of payment.

Special Clauses. The Articles of Agreement may properly contain special clauses providing for the handling of different contingencies that may arise in the performance of the work; and it is the duty of the Engineer to foresee all possible complications that may arise, and to provide means of protecting the parties in case of such complications.

The specifications usually provide for extra work, alterations in plans and specifications, and settling of disputes; in which case, special reference to the plans and specifications, etc., renders it unnecessary to refer again to them in the Agreement; but if the specifications do not so provide, special clauses should be inserted in the agreement.

Date. The contract may be dated in either the beginning, or the closing clauses, or both. It is not well to write out the date in full in both clauses.

Seals. As already stated, when corporations are parties to contracts the corporate seal should be attached. When individuals are parties to contracts a scroll around the word "seal" written with ink is generally considered sufficient. The initials of the signer should be written across the "seal".

Witness. A notary public is the best witness to a contract, as it is easy to locate him and prove his authority in case of doubt as to the authenticity of the signature.

Conclusion. The usual wording for the conclusion of the agreement is:

IN WITNESS WHEREOF, the parties herein named have hereunto set their hands and seals, the day and year herein first above named.

By John Smith
(Party of the first part)
President

Attest: [SEAL]
James Jones
Secretary

Witnesses:
William Brown ..... [SEAL]
..... [SEAL]
James Malone [SEAL]
(Party of the second part)
Contractor

TYPICAL AGREEMENTS

The following forms of agreement will be of service to the student. The order in which the clauses are arranged is not vital, and none of the forms contain all of the suggested clauses, so the Engineer in drawing the agreement must be governed by the conditions surrounding the work and the parties.

General Form

THIS AGREEMENT, Made this twenty-second day of September in the year of our Lord one thousand nine hundred and ten (1910), between the Ohio Railroad Company, a corporation of the State of Ohio, hereinafter called the party of the first part, and Patrick

O'Conner, Contractor, residing at 128 Washington Avenue, City of Wilmington, State of Delaware,

hereinafter called the party of the second part,

WITNESSETH, That the said party of the second part, for and in consideration of the payments hereinafter specified and agreed to be made to the Contractor by the said party of the first part, hereby covenant, contract, and agree, to furnish and deliver all the materials, and to do and perform all the work and labor required to be furnished and delivered, done and performed in building Section No. III of the Imton Extension of the Ohio Railroad from Greenburg to Graytown, all in the State of Ohio, including grading, masonry, buildings, track, and signals, complete and ready for operation, all

in strict and exact accordance with the proposal and specifications hereto attached, which said proposal and specifications are hereby made a part of this agreement as fully to all intents and purposes as though herein set out at length.

The said party of the second part further contract and agree that all of the materials used in the said work shall be of the best of their several kinds and qualities, and that all of the said materials and work shall be subject to the inspection and approval of the Chief Engineer of Ohio Railroad Company and in case any of the said materials or work shall be rejected by the said Chief Engineer as defective or unsuitable, then the said materials shall be replaced with other materials, and the said work shall be done anew immediately, to the satisfaction and approval of the said Chief Engineer at the cost and expense of the said party of the second part.

It is further distinctly understood and agreed that the said work shall be completed on or before the First day of January, nineteen hundred and twelve (1912) and if the said work be not completed within the time specified, it is understood and agreed that the sum of One Hundred Dollars ($ 100) per day shall be deducted from the amount due the said party of the second part for each and every day the said work shall remain incomplete or unfinished after the said time, not as a penalty, but as ascertained and liquidated

damages; which sum so deducted shall remain the property of the said party of the first part. Or shall the said part y of the second part in the opinion of the said Chief Engineer be prosecuting the said work with an insufficient stock of materials for the prompt completion thereof within the specified time, or be improperly performing the said work, or shall the Contractor neglect or abandon it before completion or unreasonably delay the same, so that the conditions of the contract are being wilfully violated or carelessly executed, or in bad faith, or shall the Contractor neglect or refuse to renew or again perform such work as may be rejected by the said Chief Engineer as defective or unsuitable, or shall the Contractor in any other manner in the opinion of the said Chief Engineer make default in the performance of this contract, then and in any such case the said Chief Engineer shall promptly notify the said party of the second part in writing of such neglect or default. If such notification be without effect within twenty-four hours after the delivery thereof, then and in that case the said Chief Engineer may notify the said party of the second part to discontinue all work under this contract; and the said Chief Engineer shall thereupon have full authority and power immediately to purchase such materials, tools, and machinery, and to employ such workmen as in his opinion shall be required for the proper completion of the said work at the cost and expense of the said party of the second part or his surety, or both; or the said Chief Engineer may, without notice, declare this contract null and void, and the security bond and the retained percentage and the material delivered and used in, on, or about the said work shall then become the property of the said Railroad Company.

The said party of the second part further contract s and agree s to properly enclose the said work, and to place signal lights thereon all night, when and where necessary, and to be responsible for and pay all loss or damage to either person or property which may, in any manner, arise by reason of the prosecution of the said work, during the progress of the same, and in case of the happening of such loss or damage the amount thereof may be retained by the said party of the first part out of any payments due or to grow due hereunder.

The said part y of the second part agree s not to assign, transfer, nor sublet this contract.

It is further understood and agreed that this contract is entered into under and subject to the provisions of the various local laws in regard to Sub-Contractors, Security, and Workmen.

In consideration of the premises, the said party of the first part agrees to pay to the said part y of the second part Two hundred and fifty thousand dollars ($250,000.).

It is further distinctly understood and agreed that the total amount to be expended for the materials to be furnished and work to be done under this contract shall in no event exceed the sum of Two hundred and seventy-five thousand ($275,000.) dollars.

PARTIES HEREIN NAMED HAVE HEREUNTO SET THEIR HANDS AND SEALS, THE DAY AND YEAR HEREIN FIRST ABOVE NAMED.

Attest:

[CORPORATE SEAL]

James White
Secretary

Witnessed by

Peter Sloan

OHIO RAILROAD COMPANY,

By John Smith
President

[SEAL]

[SEAL]

[SEAL]

Patrick O'Connor
Contractor

Railway Form

As already stated, there is a great difference of opinion as to whether certain clauses be placed in the agreement or the specification.

There are many conditions affecting contracts that an engineer generally does not appreciate. It is advisable, therefore, to submit the contract and bond before execution to an attorney, for advice as to whether all the requirements of the law have been complied with.

The following form of agreement is that used by one of the

great trunk lines of the country, for their contracts for Grading, Masonry, Trestlework, Tunnels, etc.

ARTICLES OF AGREEMENT, Made and concluded this twenty-first day of June A. D. 191 4, by and between Fast Line Railroad Company, a corporation of the State of New Jersey, of the first part, and Reliance Contracting Company, a corporation of the State of New Jersey, second part.

WITNESSETH, that for and in consideration of the covenants and payments hereinafter mentioned to be made and performed by the said party of the first part, the said party of the second part hereby covenant s and agree s subject to the approval and to the satisfaction and acceptance of the Chief Engineer of the said rail road Company to build the substructure of the Green River Bridge to do and to finish in a substantial and workmanlike manner, and in strict conformity with the annexed specifications, hereby adopted, accepted, and declared by the parties hereunto to be an essential part of this agreement, the entire work of building cofferdams, excavating same to hard rock bottom, and building all the piers and abutments of the Green River Bridge

And it is mutually agreed between the said parties of the first and second parts, that

1. *Right of Way.* The right of way and use of such lands as may be necessary to enable the said party of the second part to conform to the requirements of the specifications here attached shall be furnished for the construction of the said railway by the said party of the first part, so that the work herein contracted for can be promptly commenced and prosecuted to completion.

2. *Work Executed under Direction of Chief Engineer.* The work shall be executed under the supervision and direction of the Chief Engineer of the party of the first part (hereinafter called the Chief Engineer, being either the regular incumbent of the office of Chief Engineer, or the person who, from time to time, may be designated by the party of the first part to be Acting Chief Engineer). Such Chief Engineer shall possess and exercise all the power hereinafter prescribed, and shall designate the portions of the line upon which work shall be begun and performed, and shall, at all proper times, furnish plans, measure-

ments, stakes, and directions for doing the work, it being distinctly understood that any action herein contemplated as to be taken by the Chief Engineer may be taken and performed, subject to his ultimate approval and adoption, by his subordinates, and when so taken and performed shall, upon such approval and adoption (but not otherwise), be in all respects taken, treated, and considered as the sole and original action of the Chief Engineer. Oral instructions in regard to any work to be performed under this agreement, if accepted by the said party of the second part, shall be accepted at his own risk, and no instructions so given shall relieve the said party of the second part from liability to damages or expenses arising from the performance of the work in accordance with such instructions, or in any other way than in accordance with this agreement, and the said party of the first part hereby reserves to itself the right to accept or reject any or all work done in accordance with such instructions.

3. *Tools, Materials, Mechanics, Laborers at Contractor's Expense.* The said party of the second part shall, at his own expense, cost, and charge, find and provide a full and ample supply of the best and most suitable tools and appliances required to be used in the performance of said work, and provide the best of material of every kind that may be needed for the thorough and expeditious execution of said work, and shall furnish and provide in sufficient numbers all mechanics, laborers, and other workmen, and also all things that may be necessary and requisite for constructing and completing, within the time herein stipulated, the whole of the work herein agreed to be done.

4. *Time of Commencement and Completion.* The work herein contracted for shall be commenced within thirty days after the date of this agreement, and shall be completed on or before July 1st 191 6. This stipulation being made with the full knowledge, understanding, and agreement by the party of the second part that the time of commencement, discontinuance, suspension, resumption, and rate of progress of any and all work contemplated in or by this contract, shall be subject and according to such directions as may, from time to time, be given by the Chief Engineer, and that, unless expressly so declared in writing by the Chief Engineer, the date of final completion shall not be postponed by reason of any such direction, or any compliance therewith; and no right of the party of the first part under any clause of this contract, nor any obligation or liability of any contractor, surety, or bondsman shall be waived, lost, or impaired by any extension of the time for performance beyond the date above fixed for completion, but every clause of

the contract or bond shall apply in respect of the time as extended by the written declaration of the Chief Engineer.

5. *Prices.* For and in consideration of the true and faithful performance of the work by the said party of the second part, according to the agreements and conditions contained in this agreement, and the specifications hereto attached, the said party of the first part hereby promises and agrees to pay, in the manner, at the times, and under the conditions hereinafter provided, to the said party of the second part, his executors or administrators, for the work done and materials furnished as aforesaid, at the following rates and prices, to wit:

	Dollars	Cents
For clearing, per acre	50	00
For grubbing, per acre	250	00
GENERAL EXCAVATION AND EMBANKMENT		
For solid rock, per cubic yard	0	85
For loose rock, per cubic yard	0	60
For earth, per cubic yard	0	30
For borrowed embankment, per cubic yard	0	25
For excavation without classification, per cubic yard	0	38
For removing old masonry, per cubic yard	1	50
EXCAVATION IN WATER		
For solid rock, per cubic yard	2	80
For loose rock, per cubic yard	2	00
For earth, per cubic yard	1	00
For excavation without classification, per cubic yard	2	50
TUNNEL EXCAVATION		
For single track tunnels, per cubic yard	4	00
For double track tunnels, per cubic yard	3	75
For shafts, per cubic yard	6	00
BALLAST		
For broken stone, per cubic yard, in place under track well surfaced	1	20
For gravel, per cubic yard, in place under track well surfaced	1	05
For slag, per cubic yard, in place under track well surfaced	1	15

	Dollars	Cents
MASONRY		
For 1st class, per cubic yard	10	00
For 2d class, per cubic yard	8	00
For 3d class, or rubble, and box culverts, in cement, per cubic yard	6	00
For 3d class, or rubble, and box culverts, dry, per cubic yard	3	50
For arch masonry, 1st class, per cubic yard	12	00
For arch masonry, 2d class, in cement, per cubic yard	10	25
For arch masonry, 2d class, dry, per cubic yard	2	75
For slope walls, per cubic yard	2	75
For stone paving, in cement, per cubic yard	3	50
For stone paving, dry, per cubic yard	3	00
For concrete No. 1, per cubic yard	8	50
For concrete No. 1, per cubic yard, $\frac{3}{4}$-in. stone, per cubic yard	8	65
For concrete No. 2, per cubic yard	7	75
For brick work, per cubic yard	12	00
For packing in cement, per cubic yard (in tunnel)	6	00
For packing, dry, per cubic yard (in tunnel)	4	25
For packing, dry, per cubic yard (back of abutments and retaining walls)	2	75
For rip-rap, per cubic yard	1	95
MACADAM AND TELFORD ROADWAY		
For Macadam paving, per square yard	0	85
For Telford paving, per square yard	0	93
IRON DRAIN PIPE		
For 4-inch, per lineal foot in place	0	55
For 6-inch, per lineal foot "	0	80
For 8-inch, per lineal foot "	0	95
For 10-inch, per lineal foot "	1	10
For 12-inch, per lineal foot "	1	25
For 16-inch, per lineal foot "	1	95
For 20-inch, per lineal foot "	2	55
For 24-inch, per lineal foot "	3	25
For 30-inch, per lineal foot "	4	95
For 36-inch, per lineal foot "	6	80
For 48-inch, per lineal foot "	11	30
For 60-inch, per lineal foot "	16	85

	Dollars	Cents
TERRA COTTA DRAIN PIPE		
For 4-inch, per lineal foot in place.....	0	40
For 6-inch, per lineal foot "	0	70
For 8-inch, per lineal foot "	1	00
For 10-inch, per lineal foot "	1	12
For 12-inch, per lineal foot "	1	29
For 15-inch, per lineal foot "	1	56
For 18-inch, per lineal foot "	1	82
For 20-inch, per lineal foot "	2	10
For 24-inch, per lineal foot "	2	67
For 27-inch, per lineal foot "	3	77
For 30-inch, per lineal foot "	4	45
For 36-inch, per lineal foot "	6	10
FOUNDATION TIMBER		
For White Oak, per 1000 feet B. M. in place....	51	00
For Yellow Pine, per 1000 feet B. M. "	53	00
For Hemlock, per 1000 feet B. M "	52	00
TRESTLE TIMBER		
For White Oak, per 1000 feet B. M. in place....	60	00
For Yellow Pine, per 1000 feet B. M. "	55	00
For Hemlock, per 1000 feet B. M. "	53	00
TUNNEL TIMBER		
For White Oak, per 1000 feet B. M. in place....	49	00
For Yellow Pine, per 1000 feet B. M. "	45	00
For Hemlock, per 1000 feet B. M. "	43	50
PILING		
For White Oak, per lineal foot left in the work..	0	48
For Hemlock, per lineal foot " " ..	0	32
For Yellow Pine, per lineal foot " " ...	0	36
TRACK LAYING		
For track laying and lining, including unloading of track materials, spacing of ties, and placing in position of switches and frogs, complete, per mile single track.....	860	00
STEEL AND IRON WORK		
For wrought iron, per pound in place, spikes, bolts, etc.	0	04
For steel, per pound in place, metal for reinforcing concrete	0	04
For cast iron, per pound in place.....	0	03

6. *Payment.* During the progress of the work, so long as the party of the second part shall fully comply with the terms of the agreement, the party of the first part shall, upon or about the 15th day of each calendar month, and at such place as may from time to time be designated by the Chief Engineer, make to the party of the second part an advance payment for and on account of the work done and material furnished during the preceding calendar month; quantity, character, and value of such work and material to be estimated and certified by the Chief Engineer or by his subordinates, with his written approval; such advance payment not to exceed ninety per cent of the value as thus estimated and certified. Such certificate may be based on either actual measurements or simple estimate, or both combined, as shall be approved by the Chief Engineer and, except as otherwise determined by the Chief Engineer, no amount so estimated and certified, nor any amount shall in any wise be deemed payable, nor shall the same in any manner be transferable or assignable either by the act of the party of the second part or by the operation of law as a subsisting debt or liability of the party of the first part, until the final estimate shall have been made and become payable as hereinafter provided, nor (except at the option of the party of the first part) until all amounts payable to laborers, sub-contractors, or material men shall have been fully paid, or the payment thereof secured to the satisfaction of the Chief Engineer. The portion of each amount so certified (being not less than a sum equal to ten per cent thereof) reserved by the party of the first part shall be by it retained forever as compensation for or on account of any damages which may be certified by the Chief Engineer to have been by it sustained from any failure of the party of the second part to perform this contract, and the work thereunder, as herein provided; but any part thereof not required as such compensation shall be payable and paid to the same persons at the same time and upon the same conditions as the final payment under this contract, hereinafter provided for. And it is further provided that, at the discretion of the Chief Engineer, a larger proportionate part than ten per cent of each monthly certificate may be retained by the party of the first part as a protection against overpayment for work done, as compared with that remaining to be done; and at all times it shall be wholly discretionary with the party of the first part to make any payments on account of material delivered, and not permanently applied to the work for which it may have been intended.

Each monthly estimate, unless it be specifically decided and therein declared in writing to the contrary by the Chief Engineer,

shall cover and certify the quantity, character, and value of all work done or material furnished since the last preceding estimate, which shall by the Chief Engineer be considered as extra work, and the acceptance by the party of the second part of the amount, payable under any monthly estimate, shall be deemed and taken (except as to that part of the price thereof being not less than ten per cent reserved and retained by the party of the first part as compensation as aforesaid) as a waiver by him of any and all claim for or on account of extra work up to that time, and each monthly estimate or certificate of the Chief Engineer shall, unless expressly therein provided to the contrary, be final and conclusive as to any and all extra work rendered or claimed to have been rendered at any time prior to the close of the month for which such estimate or certificate shall be given.

7. *Monthly Estimates Conclusive Only for the Time Being, and Subject to Variation.* Every monthly estimate shall, for the time being be conclusive upon both parties hereto, but being made (except as above provided as to extra work) merely as a basis for payment on account, though with a great desire and effort for accuracy, may be only approximately correct, and therefore shall (except as above provided as to extra work) be subject to correction by the Chief Engineer in any subsequent monthly estimate, or in any final estimate; and no such monthly estimate or certificate for unfinished work shall be considered or taken as an acceptance of the work, or as a release of the said party of the second part from responsibility therefor, nor as controlling the Chief Engineer in the final certificate, which alone shall operate as an acceptance of the work or as a release of the party of the second part.

8. *Final Estimates and Payments.* When this agreement in all its parts and in the manner therein provided shall have been completely performed on the part of the said party of the second part, and such performance shall have been accepted and so certified in writing by the said Chief Engineer, a final estimate of the quantity, character, and value of the work done and materials furnished, according to the terms of this agreement, shall be made by the Chief Engineer, and thereupon and not otherwise or sooner, except at its own election, the said party of the first part shall within 90 days thereafter, pay to the said Contractor, upon his giving a release under seal to the said party of the first part from all workmen and material men, of all claims or demands whatsoever growing in any manner out of this agreement, all sums of money so certified by the Chief Engineer to be then remaining due and unpaid upon the work performed under this agreement, after first deducting therefrom

any and all sums herein provided to be retained by the said party of the first part, it being expressly understood that such final estimate and certificate of the Chief Engineer shall be conclusive upon the parties to this contract.

And it is further distinctly understood and agreed:

1. *Must Obtain Consent to Sublet.* The said party of the second part shall not assign or sublet the whole, or any part of this agreement (for any work to be done thereunder) without first having obtained the consent, in writing, of the said part of the first part thereto.

2. If at any time during the progress of the work it shall appear to the Chief Engineer (*a*) that the work does not progress with reasonable speed; or (*b*) that the force employed, the quantity or quality of the tools, appliances, or workmen provided, or work done or materials furnished are not respectively such as to insure the completion of the work within the agreed time, or are not in accordance with the specifications hereto annexed; or (*c*) that the party of the second part has unreasonably failed to pay laborers and workmen or overseers for work performed under this agreement; or (*d*) that legal proceedings have been instituted by parties other than the party of the first part, against the party of the second part in such manner as to interfere with the prosecution of the work, or to subject the party of the first part in making further payments under this contract to the peril of litigation or outside claims; or (*e*) that the party of the second part is failing in any manner of substance to observe and perform this contract; then, and in any of such events, such fact or condition may be fully ascertained and declared by the Chief Engineer, over his signature, in a writing to be filed with the party of the first part, and a copy thereof shall be served upon the party of the second part, either in person or by mailing the same to him at the address by him last given to the party of the first part, or by posting the same on the door of his office on or near the work, and at any time after the service as aforesaid of such certificate of the Chief Engineer may take any of the following courses:

(*a*) *Penalty.* The Chief Engineer may, by a writing similarly served (of which a copy shall be filed with the party of the first part), declare this contract terminated and annulled, and from the time of such service this agreement, and every part thereof, shall cease and terminate, and shall, as to all further action or right thereunder (including any right of the party of the second part, or any one claiming under him, to receive the unpaid value of any work done), become null and void, except that all sums theretofore reserved by the party of the first part

shall belong to and be retained by the party of the first part as liquidated compensation receivable by the party of the first part for the damages not susceptible of exact ascertainment caused the party of the first part by such failure of the party of the second part; or,

(*b*) *Penalty.* The Chief Engineer may, by a writing similarly served (of which a copy shall be filed with the party of the first part), declare that the party of the second part has grossly violated this contract, and that the contract is, therefore, forfeited and the party of the second part in gross default, in which event the party of the second part shall have no further right under this contract, or concerning any work theretofore done thereunder, but, nevertheless, he and his sureties shall compensate the party of the first part for any and all loss or damages which may, from time to time, be certified by the Chief Engineer to have in any wise resulted from such gross violation, ascertained as aforesaid; or,

(*c*) *Penalty.* The Chief Engineer may by a writing similarly served (of which a copy shall be filed with the party of the first part), require the party of the second part to at once supply such increase of force, appliances, or tools, and to cause to be made such improvements in the character of the work and material as may be required in the opinion of the Chief Engineer, to make the same conform to the stipulations of this agreement and the specifications; and if, on the expiration of ten days after such service of such writing, the party of the second part shall have failed to furnish to the party of the first part evidence satisfactory to the Chief Engineer of the intention and ability of the party of the second part to furnish the desired improvements and remedy the specified deficiencies, the said party of the first part may thereupon enter on and take possession of the said work, or any part thereof, with the tools, materials, plants, appliances, houses, machinery, and other appurtenances thereon, and hold the same as security for any or all damages or liabilities that may arise by reason of the non-fulfillment of this agreement within the time herein stipulated; and, furthermore, may employ the said tools, materials, etc., as aforesaid, and such other means as the said party of the first part may deem proper to complete the work at the expense of the said party of the second part, and may deduct the cost of completing the entire work from any payments then due or thereafter falling due, to the said party of the second part, and recover from him and his sureties any and all deficiency.

And immediately upon, from, and after the service, as aforesaid, of any of the three writings last mentioned, all right of

occupancy in or upon any lands or property of the party of the first part; and all rights of the party of the second part, or of any person claiming under or through him any further prosecution of or interest in the work shall cease and determine, and the party of the first part may take possession of such lands or property and complete the work thereon in such manner and by such means as it may think best.

And it is further agreed and understood that if, at any time, the party of the second part shall refuse or neglect to prosecute the work with a force sufficient, in the judgment of the Chief Engineer, for its completion within the time specified, then, and in that case, the party of the first part may proceed to employ such a number of workmen, laborers, and overseers as, in the opinion of the Chief Engineer, may be necessary to insure the completion of the work within the time hereinbefore limited, at such wages as the party of the first part may find necessary or expedient, and may pay all persons so employed and charge all amounts so paid as so much money paid to the party of the second part under this contract.

It is further agreed and understood that if the said party of the second part shall not complete the said work within the time herein specified, and the said party of the first part shall, notwithstanding such failure, permit the said party of the second part to proceed with or complete the said work as if such time had not elapsed, such permission shall not be deemed a waiver in any respect, by the said party of the first part, of any forfeiture or liability for damages or expenses thereby incurred arising from such noncompletion of the said work within the time specified, but such forfeiture or liability shall still continue in full force against the said party of the second part as if such permission had not been granted. And it is further distinctly understood and agreed, that time, whenever involved in this agreement, is of the essence of this agreement.

3. *Nonpayment of Wages.* In all cases of nonpayment by the said party of the second part of any sum or sums of money due the laborers or other workmen, for work performed under this agreement, the said party of the first part is hereby authorized to pay such laborers or workmen the amounts due and owing to them by the said party of the first part; and if any action or proceeding at law or in equity shall be instituted, by virtue of any law or statute now in force, or hereafter enacted, for labor and wages on said work, the said party of the first part may pay all damages, wages, recoveries, costs, expenses, and counsel fees arising therefrom, and deduct the same, and also whatever amounts may be paid for wages as before mentioned, from any

moneys due or to grow due to the said party of the second part; and the said party of the first part may, from time to time, retain such reasonable sums as it may deem necessary for its protection in this behalf, and the said party of the second part shall forthwith pay to the party of the first part the amount of any deficiency arising from such payment of laborers or other workmen, and the retention from time to time of such reasonable sums as it may deem necessary for its protection in this behalf, and the said party of the second part shall pay the deficiency arising therefrom upon demand.

4. *Discharge of Employes for Cause.* The said party of the second part shall discharge any foreman or other employe who shall, in the judgment of the said Chief Engineer, be unfaithful, unskillful, or remiss in the performance of his work, or guilty of riotous, disrespectful, or otherwise improper conduct; and no person so discharged from this work, or any other work done for the said party of the first part, shall be employed again by the said party of the second part upon the work to be done under this agreement, without the written consent of the said Chief Engineer.

5. *Use of Intoxicants.* The use or sale of ardent spirits, or other intoxicating beverages upon the work, or in any of the buildings, boarding houses, or other tenements owned, occupied, or within the control of the said party of the second part, or any of his employes, is strictly forbidden, and the said party of the second part shall exercise his influence and authority to the utmost extent to secure compliance with this regulation.

6. *Contractors to be Held Responsible for Violations of Laws and Ordinances.* In all operations connected with the work embraced in this agreement the said party of the second part shall be held responsible for any failure to respect, adhere to, and comply with all local ordinances and laws controlling or limiting, in any way, the actions of those engaged upon the work, or affecting the materials, or the transportation or disposition of them. And the said party of the second part hereby assumes all liability for, and agrees to indemnify the said party of the first part against all loss, cost, or damages for or by reason of any liens, claims, or demands for materials, or from laborers, mechanics, and others, and from any damages arising from injuries sustained by mechanics, laborers, or other persons, by reason of accidents or otherwise, and from damages sustained by depositing materials to public injury, or to the injury of any person or corporation, including costs and expenses of defense, provided that he be duly notified of the bringing of suits in such

cases, and be permitted to defend the same by his own counsel, if he should so elect.

7. *Contractor to be Responsible for Damages.* Where the line of the railway passes through farms, the said party of the second part shall keep up such temporary fences as may be necessary for the preservation of the crops thereon. The said party of the second part shall be responsible for any damages that may be done by him or his workmen during the performance of this work to property adjacent to the line, in consequence of his or their unskillfulness or negligence; and if any such damage shall be done, the said Chief Engineer shall have the right to settle and pay the same; and deduct the amount thereof from the payments to be made upon the estimates. Whenever any work herein embraced shall in any manner interfere with a public or private traveled road, the said party of the second part shall keep a temporary roadway, during such interference, at all times unobstructed and safe for travel, and any damages which may result from failure so to do may be settled and withheld, as above, until paid by the said party of the second part.

8. *Material and Labor Not Provided for in Specification to be Done and Furnished on Written Order of Chief Engineer.* If, in the course of the performance of this contract, or any work thereunder, it shall, according to the written opinion of the Chief Engineer, become necessary for the party of the second part to do any work or to furnish any material not embraced in the foregoing classification, or for which no price is hereinbefore specified, then and in that event the party of the second part shall, if ordered in writing by the Chief Engineer, under and according to his directions, do all such work, and furnish all such material, and upon performance to the satisfaction of the said Chief Engineer, the party of the second part shall at the periods and in the manner herein provided for payments under the contract, receive therefor the reasonable value thereof, as the same shall be ascertained and determined by the Chief Engineer, at approximately the rate of payment above fixed for work or material (if any such there be) of substantially similar character; or, at the discretion of the Chief Engineer, a separate contract for such work and material (if any) may be entered into by the party of the first part with any person, and the person so contracting shall be permitted free access and facility in performing such work and furnishing such material, it being intended hereby to exclude, as far as possible, any claim for "extra" work (so-called), and to provide for the most prompt, expeditious, and economical prosecution of all work necessary to the principal undertaking.

9. *Chief Engineer May Alter Line, Location, etc.* The said Chief Engineer shall have the right to make any alteration that may hereafter be determined upon by him as necessary or desirable in the location, line, grade, plan, form, or dimensions of the work, either before or after the commencement of the same, defined in writing, and by, or without drawings; and in case such alterations increase the quantities, the said party of the second part shall be paid for such excess at the contract rates herein specified; but should such alterations diminish the quantity or extent of the work to be done, they shall not, under any circumstances, be construed as constituting and shall not constitute a claim for damages, on any ground whatever, nor shall any claim be made on account of anticipated profits, nor on any account whatever in respect to the work which may be altered or dispensed with, the intent of this provision being that only the work absolutely done shall be paid for, and at the prices named in this agreement.

10. *Claim for Extra Work.* No claim for extra work shall, under any circumstances, be made, allowed, or considered, unless the same shall have been done in pursuance of an order given in writing, as above provided, by the said Chief Engineer; but nothing shall be deemed or construed as extra work which can be classified, measured, and estimated under the terms of this agreement.

11. *Allowance for Delays.* No extra compensation shall be made to the said party of the second part for hindrances or delays from any cause in the progress of any portion of the work performed under this agreement; but if such delays or hindrances arise from any cause other than the fault of the said party of the second part, then and in that case, the said party of the second part shall be entitled to such extension of time for the completion of this contract as shall, in the opinion of the said Chief Engineer, be sufficient to compensate for any such detention, provided the said party of the second part shall give notice, in writing, to the said party of the first part of such hindrances and delays, stating the cause thereof, within twenty-four hours after the same shall first occur.

12. *Right to Suspend Work.* The said party of the first part reserves the right to suspend or terminate the work embraced in this agreement for reasons not herein specified, and the said party of the second part hereby agrees to discontinue all work within ten days after receiving notice of such suspension or termination, in which case, the said party of the second part shall be entitled to payment in full for all materials actually handled or supplied, at a valuation to be fixed by the Chief Engineer, subject to review, as hereinafter provided, but shall make no claim

for consequential damages or anticipated profits upon work not actually performed or damage of any kind resulting from such suspension or termination.

13. *Repairs in Case of Defective Work.* Any replacement or repairs rendered necessary upon or about the work herein contracted for, by reason of defective material or workmanship furnished or performed by the said party of the second part, shall be made by the said party of the second part upon demand, without cost or expense to the said party of the first part.

14. *Chief Engineer to Settle Disputes.* All questions, differences, or controversies which may arise between the parties hereto in regard to any work to be done under this agreement, whether as to its performance or non-performance, or in any way whatever pertaining to or connected with said work, shall be referred to the said Chief Engineer, and his decision shall be in the nature of an award, and shall be final and conclusive upon both parties, and compliance on the part of the party of the second part with every such decision of the Chief Engineer shall be a condition precedent to the right to receive any payment hereunder.

15. *Modification of Contract.* This contract, and any and every provision thereof, may be modified or extended by the mutual agreement of the parties hereto.

16. *Security.* The contractor will be required to give an approved trust company's bond in the sum of one-half the amount or approximate amount of the Contract, for the faithful execution and completion of the work.

IN WITNESS WHEREOF, The parties herein named have hereunto set their hands and seals, the day and year herein first above named.

Attest:

[CORPORATE SEAL] FAST LINE RAILROAD COMPANY,

James Brown Secretary By John Smith President

RELIANCE CONTRACTING COMPANY, [L. S.]

[SEAL] By Michael Shinn Pres [L. S.]

Contractor

Attest:

Henry L. Price

Secretary

The following "Directions as to Execution of Contracts" are issued by the United States Government in connection with some of its contracts, and may be studied to the advantage of the student of this subject:

1. The papers should be made in quadruplicate, and each copy should be the exact counterpart of the others, so that any one of them may be used as an original.

2. Before signatures are appended to the papers, all dates should be written in, and all remaining blank spaces ruled out, with ink.

3. Interlineations and erasures are to be avoided when possible; but when they are unavoidable, either in the specifications, the contract, or the bond, they should be noted, word by word, immediately above the signatures of the witnesses, specifying the number of each line where they occur; and certificate should be made that each specific correction or alteration was made before the contract was signed. A general statement that "erasures and interlineations were made before execution" is wholly insufficient.

4. The full name and residence of each signer of contract and bond should be stated in the body of the instrument and the signature of each person should be witnessed by two other persons who should state their places of residence.

5. When firms contract, the name of the firm and the full name of each member thereof should be written at the beginning of the contract; for instance, "Smith, Brown & Co., of the City of New York, a firm composed of John S. Smith, Charles B. Brown, and John W. Robinson". The contract should be signed in the firm name, viz: "Smith, Brown & Co., by John S. Smith". The bond given to guarantee fulfillment of a firm contract should be in the name of the individuals composing the firm and should be signed and sealed by each of them, or by his duly authorized attorney, proof of whose authority must be attached.

6. When an incorporated company enters into contract, the corporate name of the company should be written at the beginning of the contract and bond; for instance, "The Smith and Brown Dredging Company, a corporation created by and existing under the laws of the State of New York, and having its principal office in the City of New York, in said State". The contract and bond should then be signed with the corporate name, by a person duly authorized to do so, sealed with the corporate seal, and a certificate, showing the signer's authority to sign sealed instruments in its behalf and that the seal affixed is the corporate seal, should be made by the secretary of the corporation or other custodian of its records, in the form prescribed. In cases where

a corporation or other body organized under law, has no seal, one must be adopted for the occasion, and proof thereof should be made by affidavit of the secretary.

7. The date of the bond must not antedate that of the contract.

8. A firm will not be accepted as surety, nor will a partner be accepted as a surety for a copartner, or for a firm of which he is a member. An officer of a corporation will not be accepted as surety for such corporation. In no case will a married woman or an infant be accepted as a surety, and when an unmarried woman (widow or spinster) is given as a surety, she must be described as such in the body of the bond; nor will a bonded officer of the United States be accepted as a surety; nor will any person be accepted who is an official or employe of any branch of the public service having to do with the contract, performance of which is guaranteed by the bond.

9. There must not be less than two individual sureties, but one corporate surety, duly qualified under the act of Congress of August 13, 1894, may be accepted as sole surety, provided it files or has filed with the Solicitor of the Department of Commerce and Labor full proof of such compliance with the act as qualifies it to act as surety in the case. The Contractor and sureties should sign (or execute) each bond. Each surety, including a corporate surety, must qualify in double the amount of the bond. Individual sureties must justify upon the form of "Bondsman's Oath" prescribed, and corporate surety companies upon the form of "Justification by Corporate Surety".

10. The affidavits or affirmations of sureties must be made before an officer authorized to administer oaths generally. The authority to administer such oath must be shown by certificate, unless the oath was taken before a judge of a court of record, or before a clerk or deputy clerk of a court of record, a United States commissioner, or a notary public, and the official seal is attached. There should be a separate and distinct impression of the official seal for each oath or affirmation. The official title should follow the signature.

11. Except in the case of proper corporate sureties, a judge or clerk of a state court of record, a judge or clerk or deputy clerk of a United States Court, a United States district attorney or one of his assistants, a United States commissioner, or a postmaster must certify that the sureties are sufficient to pay double the penalty of the bond.

12. An adhesive seal should be affixed to the signature of each principal and surety upon the bond, except when the prin-

cipal or surety is a corporation, in which case the corporate seal should be affixed.

13. When contracts and bonds have been thus prepared, and signed and sealed by the officer making them in behalf of the United States, they should be forwarded to the Board for its approval and the approval of the Secretary of Commerce and Labor.

14. When approved by the Board and by the Secretary of Commerce and Labor, one copy shall be returned to the officer making the contract, for delivery to the Contractor.

PROPOSALS

Proposals or bids are offers or tenders to do a certain thing or to perform certain work, on certain conditions, for a consideration. They are generally in writing.

The Engineer should prepare a blank form of proposal for the bidders to use in making the tender, with the necessary instructions as to the manner in which it is to be filled out, the limit of time when bids will be received, etc.

Notice to Bidders. The notice or instructions to bidders should give the necessary information and instructions, and should cover the following:

The form in which the bids should be sent.

The party for whom the work is to be done.

That the Contractor be skilled and regularly engaged in the line of work bid for.

When and where the plans and specifications can be obtained.

What, if any, deposit must be made with the Company before taking out a set of the plans and specifications.

How to endorse the proposal.

The date and hour when the reception of bids will be closed.

Bidder to visit the site of the work.

Bidder to examine the plans carefully.

Bidder to give the number of days required to do the work and date of completion.

Bidder to follow the printed form.

Bidder to make no conditional bid.

Bidder to write amounts as well as to give figures in filling out proposal.

Bidder to furnish guarantee to enter into contract within .....days of award of contract.

The amount of the one or more bids required (if any) and their character.

The Company's right to reject any or all bids, or to accept any bid.

The relation between the Company and the successful bidder during the period between the acceptance of bid and the execution of the contract.

That a foreign corporation (one chartered in another State than that in which the proposal is to be tendered) must furnish, with its proposal, a certificate from the state authorities entitling it to do business within said State.

That the proposals must contain no omissions, erasures, alterations, additions not called for, nor conditional bids.

In addition to the above, the notice should call the bidder's attention to local laws affecting the employment of labor and the necessity of signing the proposal with the individual's name and place of residence, as well as the firm's name and business address.

If quantities are set forth in the notice, a clause should state that the quantities used are necessarily approximate, and that the Company reserves the right to increase or decrease them. The purpose of sometimes placing the approximate quantities in the notice to bidders is to use them as a basis of comparison to determine the lowest bidder, in unit price contracts.

INSTRUCTIONS TO BIDDERS*

U. S. Government Lighthouse Board. The following instructions to bidders are used by the United States Government in the proposals of the Lighthouse Board. A study of them will give much information on the subject.

(1) All bids and guaranties must be made in duplicate upon the printed form attached hereto, which must not be detached.

* Failure to comply with these instructions renders the bid informal and liable to be rejected.

(2) Each bid must state in words, as well as in figures, the sum for which the entire work, as shown on the plans and described in the specifications, will be completed and delivered at such time as is named in the specifications.

(3) The work will be subject to the personal supervision of the Lighthouse Engineer or his agent, and all facilities must be afforded him for inspecting the materials and workmanship.

(4) All blanks in the form of bid or guaranty must be filled in. Interlineations and erasures in the bid and guaranty are to be avoided, but when they are unavoidable they should be specifically noted word by word by the signers as having been made before execution. The general statement that "erasures and interlineations were made before execution" is insufficient.

(5) No bid will be received by telegraph.

(6) The bidder's place of residence, with county and State, must be given after his signature, which must be written in full.

(7) Anyone signing a bid as the agent of another, or of others, must file with it legal evidence of his authority to do so.

(8) When firms bid, the name of the firm and the full name of each member thereof should be written at the beginning of the bid; for instance, "Smith, Brown & Co., of the City of New York, a firm composed of John S. Smith, Charles B. Brown, and John W. Robinson". The bid should be signed in the firm name by a member of the firm, thus, "Smith, Brown & Co., by John S. Smith, a member of the firm". When corporations bid, the bid should be signed with the corporate name by some person duly authorized to do so (evidence of whose authority should be appended), and sealed with the corporate seal.

(9) Bidders should satisfy the United States of their ability to furnish the material and perform the work specified. Lack of evidence of such ability will be sufficient cause for rejection of any bid.

(10) Reasonable grounds for inferring that any bidder is interested in more than one bid for the same item will cause the rejection of all bids in which he is interested.

(11) Bids submitted by different members of the same firm or copartnership will not be considered.

(12) The right is reserved to reject any or all bids or any part of a bid, to strike out any item or items in the specifications, and to waive any defects.

(13) All bids must be signed and inclosed in an envelope indorsed "Proposals for the construction of buildings at Punta Gorda Light Station, California", and then inclosed in another envelope and either delivered in person to the office of the Engi-

neer of the Twelfth Lighthouse District at San Francisco, Cal., or addressed and sent to him through the mail, postage prepaid.

(14) All bids will be publicly opened and recorded at the time specified in the advertisement. Bidders are invited to be present and to witness the opening of the bids.

(15) The contract will be in the form attached hereto, and bidders are understood as accepting the terms and conditions contained in such form of contract.

(16) The accompanying advertisement, plans, and specifications, together with these instructions, will form a part of the contract.

(17) Should the bidder to whom the contract may be awarded fail to enter into contract within 10 days after notice is given him that his bid has been accepted, he will be considered a defaulting bidder, and recommendation will be made to the Secretary of Commerce and Labor that thereafter no proposal of his be considered.

(18) A bond, with one corporate surety or two individual sureties, in the sum of 25 per cent of the amount of the bid, will be required for the faithful performance of the contract, conditioned also that the Contractor shall promptly make payment to all persons supplying him or them with labor or materials in the prosecution of the work provided for in such contract. Each surety will be required to justify in double the amount of the bond. If at any time during the contract period the Secretary of Commerce and Labor deems the security furnished by the Contractor insufficient, additional security may be required.

(19) A firm will not be accepted as a surety or guarantor, nor will a partner be accepted as a surety or guarantor, for a copartner or for a firm of which he is a member. An officer of a corporation will not be accepted as a surety or guarantor for such corporation. A married woman or an infant will not be accepted as a surety or guarantor under any circumstances.

(20) No bid will be accepted or contract entered into until approved by the Lighthouse Board and the Secretary of Commerce and Labor.

(21) Transfers of contracts, or of interests in contracts, are prohibited by law. (See U. S. R. S., sec. 3737.)

(22) Payment for the work will be made upon the certificate of the agent of the Lighthouse Board that it has been completed and delivered according to contract.

(23) The entire work must be completed and delivered at the time provided for in the specifications and contract.

(24) Any expense incurred by the United States on account of failure on the part of the Contractor to perform the service

for which he has entered into contract will be sufficient to cause the annulment of the contract, should the Lighthouse Board, with the approval of the Secretary of Commerce and Labor, so decide.

(25) No proposal will be considered unless accompanied by a guaranty or a certified check in manner and form as directed in these instructions.

(26) The guaranty attached to each copy of the bid must be signed by two responsible guarantors, to be certified as good and sufficient guarantors by a judge or clerk of a United States court, a United States district attorney or one of his assistants, a United States commissioner, a postmaster, or a judge or clerk of a state court of record, with the seal of said court attached, or by a guaranty or surety company duly authorized in accordance with the provisions of an Act of Congress approved August 13, 1894.

(27) Each guarantor must justify in the sum of 20 per cent of the amount of the bid. The liability of the guarantors and bidder is expressed in the guaranty attached to the bid.

(28) Plans and specifications must accompany bid.

(29) No person who has failed to perform satisfactorily any contract with the United States or to abide by any bond or guaranty given by him for the performance of any contract or proposal will be accepted as guarantor.

(30) In lieu of the guaranty a certified check in a sum equal to one-fourth of the amount of the bid, payable to the order of the Secretary of Commerce and Labor, will be accepted, and the proceeds of such check shall become the property of the United States, if, for any reason whatsoever, the bidder, after the opening of bids, withdraws from the competition, or refuses to execute the contract and bond required in the event of said contract being awarded to him. All checks submitted will be returned to the bidders immediately after the approval of the contract and bond executed by the successful bidder.

(31) The attention of intending bidders for this work is invited to an Act of Congress approved August 1, 1892, which provides that the service and employment of all laborers and mechanics employed by any contractor or subcontractor upon any of the public works of the United States or of the District of Columbia is limited and restricted to 8 hours in any 1 calendar day, and that it shall be unlawful for any such contractor or subcontractor whose duty it shall be to employ, direct, or control the services of such laborers or mechanics to require or permit any such laborers or mechanics to work more than 8 hours in any calendar day, except in case of extraordinary emergency. A violation of this statute is punishable by a fine or imprisonment, or by both fine and imprisonment.

Provisions for Recording Prices. The notice to bidders should be attached to the form of proposal and form a part of the contract. In the form of proposal it is well to have under the head of Price Bid, two columns; one headed dollars, the other cents, as given below:

Wrought iron, per pound, no dollars three cents
Concrete, per cubic yard, five dollars sixty-five cents
Bessemer steel rails, per ton, twenty-nine dollars no cents

PRICE BID

Dollars	Cents
No	03
5	65
29	00

The greatest number of mistakes are generally made by bidders in placing the decimal point in the wrong position. The above suggested form helps to prevent this. Of course mistakes in formal bids cannot be rectified after the bid has been opened, no matter how apparent the error may be.

The following cautionary clause is sometimes inserted in the form of proposal:

Caution—Bidders are cautioned against placing a dollar bid in the cents column, and the reverse; as any error of this character, no matter how obviously it may be an error, will cause the rejection of the whole bid as being informal.

TYPICAL PROPOSALS

The following will illustrate the wording used in describing various items in proposals.

PROPOSAL I

(City, County, and State) (Date) January 15, 191 4
To the Commissioner of Bridges, City of Bergen, State of Wisconsin.

Sir:—We hereby propose to furnish all materials, appliances, labor, and transportation necessary to perform the work, and submit to all conditions as represented, intended, and implied, both particularly and generally, in the specifications and articles

of agreement, for the concrete arch bridge over Black Creek, examined at the office of the City Engineer, and also in the Ordinance of Councils, for the construction of the said work, and perform all additional work that may be required, upon the following terms, to wit:

Item No. 1. For all excavations of all classes of materials, per cubic yard, the sum of two dollars fifty cents

Item No. 2. For concrete, Class A 1-3-6, per cubic yard in place, the sum of eleven dollars eighty cents

Item No. 3. For terra cotta sewer, 12 inches and under in place complete, with all appurtenances per linear foot, the sum of two dollars ten cents

Item No. 4. For vitrified-brick pavement, in place per square foot, the sum of no dollars thirty cents

Item No. 5. For reinforcing steel, in place, per pound, the sum of no dollars five cents

Item No. 6. For placing city hydrants, each the sum of fifteen dollars twenty cents

PRICE BID	
DOLLARS	CENTS
2	50
11	80
2	10
0	30
0	05
15	20

NOTE.—When it is likely that some additional work will have to be done by force account, it is wise to have the bidder quote a price per hour, for the various classes of additional labor and use of machinery, the items appearing in the proposal as follows:

Additional Work. For additional labor and use of machinery of the various classes enumerated below, as ordered by the Chief Engineer, including cost of superintendence, use of tools, repairs, oil, waste, and fuel.

Item No. 7. For foreman, per hour, the sum of no dollars seventy-five cents

Item No. 8. For riveter, regular working hours, per hour, the sum of no dollars sixty cents

PRICE BID	
DOLLARS	CENTS
0	75
0	60

	PRICE BID	
	DOLLARS	CENTS
Item No. 9. For riveter, overtime, per hour, the sum of no dollars ninety cents	0	90
Item No. 10. For use of team (2 horses and wagon), including driver, per hour, the sum of no dollars seventy cents	0	70
Item No. 11. For use of boiler and hoisting engine, per hour, the sum of no dollars seventy-five cents	0	75
Item No. 12. To be added to all additional materials specially purchased by the Contractor by written order ten per cent		

We agree to complete the whole of the work in 180 working days from the date of notice from the Chief Engineer to proceed.

WITNESS our hand, this 15th day of January, 1914.

John B. Smith, James S. Jones,
William F. Brown

Trading as SMITH, JONES & BROWN, Contractors.

NOTE.—The Contractor shall here give individual as well as firm names.

Address 14 South Front Street, Chicago, Illinois.

The following is a form of guaranty for the bidder executing contract within 10 days of the notice that his bid has been accepted. It should be attached to the proposal, as a part thereof.

GUARANTY

The Standard Construction Company of 17 Wall Street, New York City, a Corporation existing under the laws of the State of New York, hereby undertakes that if the bid of ten thousand five hundred dollars herewith accompanying, dated January 15, 1914, for the construction of the Little Falls bridge on the line of the Ontario Central Railroad,

be accepted as to any or all of the items bid for, the said bidder Standard Construction Company will, within ten (10) days after notice of award of contract, enter into a contract with the Ontario Central Railroad Company, to perform all work specified therein at the prices offered by said bid, and will give bond with good and sufficient surety or sureties, as may be required, for the faithful and proper fulfillment of such contract. And said Corporation binds itself and its successors to pay the Ontario Central Railroad Company, in case the said bidder shall fail to enter into such contract or give such bond within ten (10) days after said notice of award of contract, the difference in money between the amount of bid of said bidder on the work so accepted, and the amount for which the Ontario Central Railroad Company may contract with another party to perform said work, if the latter amount be in excess of the former.

IN WITNESS WHEREOF, The name and corporate seal of said corporation has been hereto affixed, this 15th day of January, 191 4, and these presents duly signed by its (1) President, pursuant to a resolution of its (2) Board of Directors, passed on the 10th day of January, A. D. 191 4.

Attest: [CORPORATE SEAL] (3)

Martin Turner
Secretary

By Henry Burke
President

(1) The president or officer authorized to sign for the Corporation.
(2) The board of directors or other governing body of the Corporation.
(3) Here affix the corporate seal.

NOTE. Instead of a guaranty of the above nature, sometimes a certified check, drawn on a national bank or trust company, is required to accompany the proposal to serve the same purpose.

PROPOSAL II

The following form of proposal may be used in railroad work:

For the grading and structures on the Straight Line Railroad from Station Ten to Station One hundred sixteen the undersigned hereby certifies that he has sufficiently examined the locality and sections of the Straight Line Railroad on which the work

proposed for below is situated; and that ..he.. ..has.. also carefully examined the specifications, terms, and conditions applicable to said work, set forth in the form herewith attached, and having made such examinations and understanding thoroughly the nature and conditions of the work to be let, the undersigned hereby proposes to the Straight Line Railroad Company to do all the work on either or all of the items to which prices are affixed in the following schedule, according to specifications, terms, and conditions aforesaid; and on the acceptance of these proposals for all or either of the items named therein, do..es.. hereby bind ..himself.. to enter into and execute the work thereon, at the following prices, viz:

	Section 1		Section 2	
	Dollars	Cents	Dollars	Cents
Grading				
(1) Clearing, per acre, the sum of	50	00	65	00
(2) Grubbing, per acre, the sum of	245	00	280	00
(3) Solid rock, per cubic yard, the sum of	1	50	1	00
(4) Loose rock, per cubic yard, the sum of	0	62	0	68
(5) Earth in cuts, per cubic yard, the sum of	0	30	0	32
(6) Earth borrowed, per cubic yard, the sum of	0	30	0	32
(7) Ditching in earth, per cubic yard, the sum of	0	22	0	25
Excavations in Water for Bridge Foundations				
(8) Solid rock, per cubic yard, in water for bridge foundations, the sum of	3	00	2	55
(9) Loose rock, per cubic yard, in water for bridge foundations, the sum of	1	45	1	45
(10) Earth, per cubic yard, in water for bridge foundations, the sum of	1	20	1	30
Masonry				
(11) First-class masonry, per cubic yard in place, the sum of	8	00	8	00

	Section 1		Section 2	
Masonry—Cont'd	Dollars	Cents	Dollars	Cents
(12) Second-class masonry, per cubic yard in place, the sum of	6	50	6	50
(13) Third-class masonry, per cubic yard in place, the sum of	4	00	4	00
(14) Slope wall, per cubic yard, in place, the sum of	2	50	2	50
(15) Rip-rap, per cubic yard in place, the sum of	2	00	2	00
(16) Concrete No. 1, per cubic yard in place, the sum of	11	00	11	00
(17) Concrete No. 2, per cubic yard in place, the sum of	7	50	7	50
(18) Concrete No. 3, per cubic yard in place, the sum of	5	75	5	75
Frame and Pile Trestle				
(19) Framing and erecting pile and timber trestles, per M feet board measure with all appurtenances in place, the sum of	55	00	57	00
(20) Pointing, shoeing, driving, and sawing off piles, per linear foot measured from "cut-off" to point, the sum of	0	13	0	14
Timber in Foundation				
(21) Yellow pine in private crossings, over meadow ditches and box drains, per M feet board measure with all appurtenances in place, the sum of	42	00	42	00
(22) Hauling and laying 12-inch double strength terra cotta sewer pipe, per lineal foot in place, the sum of	0	14	0	16
(23) Hauling and laying 18-inch double strength terra cotta pipe, per lineal foot in place, the sum of	0	28	0	28

Timber in Foundation—Cont'd	Section 1		Section 2	
	Dollars	Cents	Dollars	Cents
(24) Hauling and laying 24-inch double strength terra cotta pipe, per lineal foot in place, the sum of	0	52	0	52
(25) Hauling and laying 30-inch double strength terra cotta pipe, per lineal foot in place, the sum of	0	80	0	80
(26) Hauling and laying 12-inch cast-iron water pipe, per lineal foot in place, the sum of	0	16	0	20
(27) Hauling and laying 14-inch cast-iron water pipe, per lineal foot in place, the sum of	0	20	0	22
(28) Hauling and laying 24-inch cast-iron water pipe, per lineal foot in place, the sum of	0	40	0	44

The undersigned further propose s to commence work on such section or sections as may be awarded to him within thirty days from the date thereof, and to complete the same on or before the 10th day of July, 191 5.

James Malone,

Signed this tenth day of January, 191 4.

Proposer's residence 805 Queen Street,

Postoffice Address Lancaster,

Pennsylvania.

THE ADVERTISEMENT

Purpose. The advertisement is of minor importance and only in government and some municipal contracts is it considered of sufficient importance to be made a part of the contract.

Under the law, most public work — that is, government, state, county, municipal, and borough work — must be advertised in a

certain number of papers, over a certain period, before the public letting takes place.

The Engineer should ascertain the requirements of the law in regard to advertising public work before drawing up a contract, as contracts have been declared invalid upon its being found that they had not been properly advertised.

Of course the object of advertising is to secure competition between parties who are engaged in the kind of business or work to be performed, and hence the advertisement should be so headed as to attract the attention of the firms capable of performing this work.

Essential Features. The advertisement should be concisely worded, as every word is an additional cost to the party for whom the work is to be done; on the other hand, it should give the following information:

(a) A heading that will attract the attention of desirable bidders.

(b) The address where plans and specifications can be seen and procured.

(c) The address where proposals will be received.

(d) The date of the insertion of the advertisement.

(e) The date and hour until which proposals will be received.

(f) The manner of presenting the bid, viz, sealed, or in duplicate or triplicate, etc.

(g) The date of opening the bids.

(h) The kind and approximate quantity of work to be done, or such information as will give an idea of the magnitude of the work.

(i) The locality where the work is to be done.

(j) The right to reject any or all bids.

(k) The name and address of the parties for whom the work is to be done, or their Agent.

Sometimes the entire matter included in the "Notice to Bidders" under "Proposals" is published. The objection to this is the great cost of so extended an advertisement.

The manner of arranging these requirements will be shown by a few examples.

TYPICAL ADVERTISEMENTS

METAL WORK

To Iron Manufacturers. (a)

Office of the Lighthouse Engineer, Third District,
Tompkinsville, New York (b).....191.....(c)

Sealed Proposals in duplicate (d) will be received at this office (e) until 12 o'clock noon (f).....
191.....(g), for furnishing the materials and labor of all kinds necessary for the completion and delivery of the metal work of the Peck's Ledge Lighthouse (h), Cockenoe Island Harbor, Conn. (i)

Plans, specifications, forms of proposal, and other information may be obtained on application to this office (b).

The right is reserved to reject any or all bids and to waive any defects. (j)

.....(k)

Lieutenant Col. of Engineers, U. S. A., Lighthouse Engineer.

(a) Heading, (b) Address, (c) Date of Insertion, (d) Manner of presenting, (e) Proposals received, (f) Bidding closed, (g) Proposals opened, (h) Character of work, (i) Locality, (j) Right to reject, (k) Party letting work.

BRIDGE WORK

The following is an advertisement for the superstructure of the ill-fated Quebec bridge:

The clause in regard to prices of labor is unusual in an advertisement. The clause in regard to other newspapers inserting the advertisement without authority is a very wise one, as it is not an unusual practice for newspapers in municipalities to insert such advertisement without orders from the proper party to do so, and then issue bills for same, which are really nothing less than blackmail.

QUEBEC BRIDGE

DEPARTMENT OF RAILWAYS AND CANALS

TENDERS FOR SUPERSTRUCTURE

NOTICE TO CONTRACTORS

Sealed tenders addressed to the undersigned and endorsed "Tender for Quebec Bridge Superstructure" will be received at this office until 12 o'clock noon, not later than September 1, 1910, for the superstructure of a bridge across the St. Lawrence River near the City of Quebec.

Plans and specifications may be seen and forms of tender obtained on and after July 1, 1910, at the office of the Quebec Bridge Board of Engineers, Canadian Express Building, Montreal, and at the Department of Railways and Canals, Ottawa.

Parties tendering will be required to accept the fair wages schedule prepared or to be prepared by the Department of Labor, which schedule will form part of the contract.

Contractors are requested to bear in mind that tenders will not be considered unless made strictly in accordance with the printed forms, and in the case of firms, unless there are attached the actual signatures, the nature of the occupation, and place of residence of each member of the firm.

An accepted bank check for the sum of $500,000.00 made payable to the order of the Minister of Railways and Canals of Canada must accompany each tender, which sum will be forfeited if the party tendering declines entering into contract for the work at the rates stated in the offer submitted and in accordance with the terms stated in the form of contract accompanying the specifications.

Checks thus sent in will be returned to the respective contractors whose tenders are not accepted.

The lowest or any tender not necessarily accepted.

L. K. J.,
Secretary

Department of Railways and Canals,
Ottawa, June 17, 1910.

Newspapers inserting this advertisement without authority from the Department will not be paid for it.

MACADAM ROADS

Denison, Texas.

Sealed proposals will be received by the Commissioners' Court of Grayson County, Texas, up to the hour of 11 o'clock A. M., on August 10, 1910, at the office of said Court in Sherman, Texas, for the construction of approximately 65 miles of macadam roadway in Road District No. 1 of Grayson County, Texas. Said district is situated in the north central part of Grayson County, in and about the City of Denison.

Profiles, plans, and specifications will be on file in the office of J. C. Field, Engineer in charge, Denison, Texas, after July 1, 1910. Copies will be sent applicants on receipt of $2.00, to be returned to depositor if bid is made. A certified check for $5,000.00 on some Grayson County bank must be deposited with each bid, to be returned to unsuccessful bidders; and to be

returned to successful bidder, upon his entering into contract and bond in accordance with his bid, within 10 days from its acceptance. Failure so to enter into contract and bond will forfeit check to district.

The right is reserved to reject any and all bids.

H. R. W.,
Auditor, Grayson Co.,
Sherman, Texas

It is useless to multiply examples of advertisements, as many examples of the requirements of a good advertisement can be seen at any time in the leading technical journals.

PRACTICE IN SPECIFICATION AND CONTRACT WRITING

GENERAL INSTRUCTIONS

Examination of Actual Work. Below will be found a few subjects for practice in specification writing. Before attempting to write a specification for any of the subjects given, the student, if possible, should go out and make careful examination of such a piece of work in process of construction. If none is available, make a minute examination of a finished structure, note its strong points and its defects, and seek a remedy for the latter, embodying the ideas in the specification to be written.

If the structure is in process of building, make a thorough examination of the character of the materials entering into the work, watch the process, question the workmen and foremen as to character of foundation and as to any special features embodied in the construction. Examine brands of materials and if better processes of construction are apparent to you, discuss the subject with the foreman or superintendent with the idea of getting his criticism of your suggestions.

Study of Good Specifications. Follow this up by collecting two or three good specifications covering the subject in hand, and make a comparative study of them.

Drawings. If drawings are to be a part of the contract, the sheets must be properly numbered and a list of them set forth in the specification, which list should be inserted just before the detailed description of the work.

Order of Headings. A complete list of headings and subheadings should be made and arranged in their proper order. This is difficult, as there are so many items which have little connection with each other.

The method generally followed is to arrange the clauses as nearly as possible in the order in which the building actually takes place in the work under consideration. For instance, in a railroad specification the headings should be arranged as follows: Clearing, Grubbing, Grading, Tunnels, Excavation, Foundations, Masonry, Pipe Drains, Timber in foundation, Timber in trestles, Bridges, Tracklaying, Surfacing, etc. Of course there are many items that cannot be arranged chronologically; often one clause or heading suggests the following one, which method, carried out consistently, will give the desired result. It is very desirable that specifications for a complete piece of construction be prop erly indexed.

The following examples are given as good subjects for practice in specification writing:

TYPICAL PROBLEMS

Examples. (1) A single-track railroad handling heavy freight traffic wishes to replace a frame trestle across a stream by a steel plate girder bridge on concrete masonry abutments; clear span 75 feet. The approaches to the bridge back of the abutments are to be filled in with material obtained by widening out an adjacent cut; material in cut, sand, and loose rock; borings show hard gravel at 25 feet. Prepare a complete specification for both sub- and superstructure. The work will eventually be sublet; the masonry to one firm and the steel to another, and the grading and foundations to still another.

The work is located in Northern New York State.

(2) A timber trestle across a meadow in the State of Washington has been burned and must be replaced at once, to open traffic at the earliest possible date. The trestle is 1650 feet long; 1100 feet of the track is but 9 feet above the marsh; the 550 feet remaining varies in depth from 9 to 22 feet; profile shows but 3 feet of earth and gravel overlying the rock at the lowest point.

Prepare a complete specification for replacing the trestle in the most economical manner.

(3) Prepare complete specification for a double-track steel bridge; tracks 13 feet center to center; span 245 feet; live load, Cooper's Class E 50; steel to be erected by a sub-contractor; bridge to be complete; ties laid ready for the rails; two coats of paint after erection.

(4) Prepare a complete specification for a concrete retaining wall 875 feet long, varying in height from 8 feet above track at one end to 24 feet at the other end. The wall is surcharged with a sandy loam embankment, 15 feet high at the end of the wall which is lowest, 2 feet high at the other. Foundations in soft ..... rock in Eastern Pennsylvania.

(5) Write a complete specification and articles of agreement for the building of a double-track electric interurban railroad 22 miles long, in Northern New Jersey. The road crosses 2 navigable rivers—one crossing is 1700 feet and the other 650 feet in length. Both loose and solid rock will be encountered; the road crosses under 2 trunk line railroads and over 4 others; it crosses at grade 3 street railways. There are on the line 2 10-foot reinforced-concrete arched culverts; 1240 linear feet of framed timber trestle on concrete footings. Rail 70 pounds per yard. Track in stone ballast. To be operated by overhead trolley. Electric current to be purchased from a local company. Station grounds to be graded.

(6) A street 1 mile long is to be paved with vitrified brick on concrete base; streets crossing 500 feet apart; soil sandy loam. One half of it is to be curbed with new granite curb. The other half has been curbed with blue stone and is badly out of line and grade. Water, gas, and electric conduits are in the street, one-half of which has to be lowered varying in depth from 1 to 5 feet at the summit.

Prepare a complete specification for the above, bearing in mind that each company owning the structures in the street will do the work of altering its pipe and conduits at the expense of the Contractor.

(7) Prepare complete specification for a curved dam to be located in Georgia. It is to be 245 feet long, built of concrete

faced with ashlar masonry; soft rock foundations with the abutting banks of the river of same material; dam will be 18 feet high above river bed; maximum depth of water is 8 feet at ordinary stages; river is subject to frequent freshets; purpose of dam is for flushing out at frequent intervals a large main sewer.

(8) Prepare specification for two docks on creosoted piles; superstructure to be of reinforced concrete; depth of water 20 feet, to be dredged to 32 feet in slip, which is 150 feet wide; docks each to be 65 feet wide and 450 feet long; concrete bulkhead between the two docks. The structure will be located at New Orleans and will have two docks, the upper one for passenger service.

(9) Prepare complete contract for a brick-arch bridge; span 70 feet; rise 12 feet; springing line 7 feet above the sidewalks; bridge carries an avenue 80 feet wide across a 70-foot street; there is on the street a double track electric railway on which cars are very frequent and travel must not be interfered with; end walls and parapet to be of first-class masonry.

(10) A Commission of the Commonwealth of Massachusetts wishes to build, in the City of Boston, a reinforced concrete chimney, 10 feet interior diameter, height 175 feet, foundation on hard blue clay.

Prepare complete contract for same including Advertisement, Proposal, with Notice to Bidders, and form of Bond required, Specifications, and Articles of Agreement.

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